

No. 90651 GRID-DIP METER

I. GENERAL

The Millen 90651 Grid-Dip Meter may be used in any of the following manners:

1. **Grid-dip oscillator** for use as an oscillating frequency meter to determine the resonant frequency of de-energized r. f. circuits.

Plate potential is applied to the Grid-Dip Meter and it becomes an r. f. oscillator. A d.c. meter in the grid return indicates relative power. When a circuit, resonant at the oscillator frequency, is coupled to the "probe" inductance, power is absorbed from the oscillator by the resonant circuit and is so indicated by a dip (decrease) in the grid meter reading. The "Grid Dipper", employed in this manner, may then be used to check the resonant frequency of a circuit without the application of power to the circuit in question. This results in a considerable saving of time, and a definite assurance of correct frequency adjustment of a circuit is obtained. Circuits may be checked or retuned before completion of the unit in which they are to be used. Only minor trimming is generally required under actual operation. Guesswork or "cut and try" methods are eliminated. Possible damage to components during initial tune up and adjustment is eliminated.

2. **Oscillating detector** for determining the fundamental or harmonic frequencies of energized r.f. circuits.

Plate potential is applied and the instrument is used as an r.f. oscillator. Instead of observing the grid-meter reading, a pair of phones is inserted in the phone jack and an audible beat may be heard when the instrument is tuned to the fundamental or harmonic frequency of a source of r.f. The frequency may be read directly from the calibrated dial.

3. **Signal generator.** The instrument may be employed for this purpose generally in place of a standard signal generator, except where special shielding or a known r.f. output voltage is required.

4. **Tuned r.f. diode or non-oscillating detector** for use as an absorption-type frequency meter. No plate potential is applied and the internal tube is used as a diode. The grid meter is then in the diode load circuit and will read up-scale (current increase) when the instrument is tuned and closely coupled to a source of r.f. energy.

II. METHODS OF COUPLING

Correct methods of coupling the grid-dip meter to circuits under tests are shown in Fig. 1. When used as a grid-dip oscillator harmonics of lumped-constant resonant circuits will not be indicated; however, other resonant frequencies are sometimes indicated. These will be due to other resonant circuits formed by circuit wiring, stray capacitances, etc. In most cases these will occur at a higher frequency. On the other hand, harmonics of antennas, transmission lines, etc. will be indicated as will be explained later in the text under the heading "antennas."

When looking for the grid dip, it will be noted that the grid current reading slowly varies as the dial is rotated; however, correct resonance is indicated when the meter takes a sharp or pronounced dip.

It is suggested that the user of the "Grid Dipper" at first set up test L/C combinations, short test antennas, etc., and check them with the instrument in order to become familiar with the coupling methods and with the general behavior and operation of the unit.

Coupling too tightly will cause a deep sharp dip and a sudden rise. This tight coupling pulls the oscillator frequency somewhat, and makes it difficult to determine the resonant frequency. Over-coupling will cause inaccuracy in determining the resonant frequency. The solution is to back the Grid Dip Meter away from the test coil until the dip is barely perceptible. With this coupling there is no difficulty in determining the resonant frequency and the measurement will be accurate.

III. APPLICATIONS

Receiver tuned circuits. Use the instrument as a grid-dip oscillator. Remove power from the receiver and resonate each tuned circuit to the desired frequency as indicated by the meter dip. Gang tuned circuits should

be aligned for tracking by checking at each end of the ganged range. A check at one or two points in between will also be helpful. Methods of electrically obtaining the desired bandspread or tracking will not be explained

here. Reference may be made to any good radio text book.

Following the above procedure, power may be applied to the receiver and the grid-dip meter employed as a signal generator for checking final alignment. A very short antenna should be connected to the receiver input terminals and the "Grid Dipper" should be placed on the bench removed from nearby conductors, and where body movements are least apt to affect the r.f. signal from the instrument. Some sort of indicating device such as an "S" meter or v.t.v.m. at the receiver detector must be used. If the r.f. signal is too strong, the receiver antenna may be shortened, or the instrument may be removed to a more remote or partially shielded location.

Where a superheterodyne type of receiver is involved and, if the receiver fails to function, it is quite possible that the receiver local oscillator is not working. This may be checked by employing the "Grid Dipper" as an r.f. diode detector or absorption type wave meter. Couple it to the oscillator coil and, if the meter does not go up-scale when the instrument is tuned to the resonant frequency of the oscillator tank, the oscillator is not functioning. An alternative method having greater sensitivity and capable of more accurate frequency measurement is to use the instrument as an oscillating detector and listen for the local oscillator beat in the headphones.

Transmitter tuned circuits. Use the instrument as a grid-dip oscillator with plate power removed from transmitter and proceed to adjust tanks to desired frequency as with receiver circuits. Tubes should be in place, and where capacitive coupling is used between stages, the grid circuit associated with following tube should be completed.

After the above procedure, plate power may be applied and final alignment made according to grid and plate meter indications. R.f. power at correct frequency in each tank may be checked by employing the "Grid Dipper" as a diode absorption frequency meter or it may be utilized as an oscillating detector. Due to its greater sensitivity in the latter state, care must be taken not to mistake audible beats from some other energized r.f. circuit. This may be checked by moving the instrument closer to the circuit under test and noting whether or not the beat increases in volume. If it does, the beat heard is from the desired circuit. Harmonics also may be heard, so it is wise to check for the beat heard at the lowest frequency.

Neutralization. Employ the instrument as a grid-dip oscillator. Remove all plate power from the transmitter. Couple the "Grid Dipper" to grid tank of stage to be neutralized, or in the case of capacitive coupling to the preceding plate tank (it is assumed that the tank has already been tuned to correct frequency). Couple fairly close and leave instrument set in position with its meter deflected at bottom of the resonant dip. Neutralization is then indicated when rotation of amplifier plate tank capacitor has no reaction on the deflected meter reading. Another method is to use the instrument as a diode absorption-type meter and proceed to neutralize in the manner normally employed when using absorption-type wavemeter, or as with similar indicating device, i.e.:

Remove plate power from amplifier stage to be neutralized, and apply power to stage driving the grid. Couple the "Grid Dipper" to the amplifier tank, tune the instrument to the driving frequency and check for the presence of r.f. in the tank as indicated by a rise in the "Grid Dipper" meter current. Adjust neutralizing capacitor until no reading is seen on the meter.

Parasitic oscillations. Apply power to transmitter and use instrument as an oscillating detector while listening on headphones for beat of parasitic oscillation. As an alternative, the parasitic frequency may be determined by using the instrument as a tuned r.f. diode or absorption type frequency meter. When parasitic frequency has thus been determined, as read from the "Grid Dipper" scale, remove power from transmitter and use instrument as a grid-dip oscillator to locate circuits or components, such as r.f. chokes, circuit wiring, etc., resonant at parasitic frequency.

Parallel resonant traps. Use as a grid-dip oscillator. Trap may be tuned or checked either before or after connecting it in desired circuit. If tuned before installation, adjustment will remain correct upon installation if its inductance is physically removed from other conductive components which may alter the inductance value. This is not usually the case, so further minor adjustment will probably be required after installation. When in the circuit, it is possible that its resonant frequency may be quite a bit off as indicated by the "Grid Dipper". Actually the trap itself will still be tuned to approximately correct frequency but the grid-dip oscillator reading may be found at some other frequency (usually lower) due to circuit "strays" across the trap.

Final precise adjustment may be made by applying power to circuit and by tuning trap under actual operation for desired effect. In many cases this will not be necessary as pre-tuning is quite accurate.

Series resonant traps. Follow same general procedure as with parallel resonant trap. To check or tune prior to installation, trap may be first connected as a parallel trap. At high frequencies or where the trap inductance is low, the lead completing the parallel circuit should be of large wire or wide copper ribbon to keep its inductance low, and care should be taken not to permit this lead to be positioned so as to add stray capacitance. Leads to be used upon final installation must also be included when external measurements are being made.

R. F. chokes. To determine self resonance of r.f. chokes, use "Grid Dipper" as a grid dip oscillator.

Measure circuit Q. Use the "Grid Dipper" as signal generator. Connect a v.t.v.m. across the circuit to be measured. Couple instrument to circuit (Fig. 1A) and resonate for maximum, or peak reading, on v.t.v.m. Note frequency at which this occurs. Then shift the instrument each side of resonance to the frequency where the voltmeter reading drops to approximately 70.7% of that at resonance. Note the frequency of these two points and calculate the circuit Q from equation "A", Appendix 1, where f_r is the resonant frequency and Δf is the difference between the "off resonance" frequencies just found. The original coupling should be adjusted for a convenient maximum reading of the v.t.v.m. and then should be left fixed at this position for the remainder of the procedure.

When the circuit Q is quite high, it may be necessary to check the frequencies with a calibrated receiver, because the "off resonance" points will occur too closely together for accurate reading on the instrument scale.

Relative circuit Q at a given frequency. Use as a grid-dip oscillator and observe character of the dip whether broad or sharp. The sharper the dip, the higher the Q.

Measurement of capacitance. Several methods may be employed. All involve the use of the "Grid Dipper" as an oscillator.

A small jig (Fig. 2) must be made, into which may be plugged any one of the "Grid Dipper" coils.

To check an unknown capacitor, it is then only necessary to clip the jig, with a coil inserted, across the unknown capacitance. Find the resonant frequency and refer to the calibration chart for value of capacitor with the coil employed. For over-all accuracy, it is best to employ one of the coils from the medium frequency range.

Due to the distributed capacitance of the coils, a slight error will be encountered at very low capacitance measurements. Likewise, due to self inductance of large capacitors, a small error will be found when measuring these. Errors will be negligible for most practical purposes.

Measurements below 50 mmf are generally not obtainable because resonance at these values usually falls out of range of the coils left available for frequency checking. For measurements below 50 mmf an additional calibrated coil is required.

For these measurements, in a great number of cases, the capacitor need not be removed from the circuit in which it is wired unless the capacitor is heavily loaded.

Another method, similar to that above, is to employ a known inductance and find the resonant frequency with the unknown connected across it. See equation "B" Appendix 1 where f is the resonant frequency in cycles and L is the inductance in henries. C_x will be in farads.

A third method, for capacitors up to about 1000 mmf, requires an inductance which is shunted by a calibrated variable capacitor. The capacitor is set at maximum and the resonant frequency of the circuit is found. The unknown capacitor is then connected across the variable and the capacitance of the latter decreased to a point where the circuit resonates at the original frequency. The difference between the first and last settings of the calibrated variable capacitor is the value of the unknown.

Measurement of inductance of r.f. coils. Connect a capacitor of known value across the coil and use the "Grid Dipper" as a grid-dip oscillator to find the resonant frequency of the resulting L/C combination. The inductance of the coil may be calculated from equation "C" Appendix 1 where L_x is in henries, C is known capacitor in farads; or reference may be made to an L/C-resonance chart.

In measuring small values of inductance, be sure to employ a low inductance standard condenser, connected to the unknown coil by

wide ribbon, in order to obtain most accurate results. Due to the distributed capacitance, especially in large coils, some slight error will result; however, if the value of the low inductance known capacitor is fairly high, the error will be negligible.

Relative Q of capacitors or inductances at a given frequency may be noted by observing the character of the dip, as previously described.

Antennas. Use instrument as grid-dip oscillator. Coupling should be made at a low impedance or high current point as shown in Fig. 1E. This point, for a half wave antenna, is at the center, and for longer wires is at points odd quarter wavelengths measured from either end. It will be observed that a full-wave antenna will not be a half-wave at exactly half its resonant frequency. This is because the end effects are found only at the antenna ends and will be absent at other points when the antenna is a full wave or more long. It is therefore always necessary to measure an antenna under the conditions desired (relating to physical and electrical length). Measurement should be made with the antenna placed as near as possible to its ultimate operating position. Checks on a given antenna at different heights or positions will show an amazing difference in antenna resonance.

If it is physically impossible to reach a low impedance point, a check may be made at a high-impedance or high-voltage point. Capacitive coupling should be used as shown at Fig. 1F. If the high impedance point involved is one of the ends, the end effect will be altered due to the presence of the instrument and the resonant frequency of the antenna will slightly decrease. This must be taken into consideration when making measurement, i.e., the reading indicated will be slightly lower than true antenna resonance (with "Grid Dipper" away from end). This difference will be about 1 to 3% and will be encountered only when checking at the ends.

In all cases it is helpful to keep in mind the physical length in feet vs. electrical length (half-wave, full-wave, etc.) as calculated approximately by formula. Unlike lumped resonant circuits, antenna harmonics are detected when using the "Grid Dipper." As previously mentioned, these harmonics will not occur at exact multiples of a half-wave.

When measurement is made, the feeders should be disconnected from the antennas. Unless the feeders happen to be perfectly

matched or terminated, true antenna resonance will not be indicated because unmatched feeders or incorrectly terminated feeders will present either a positive or negative reactance and will, therefore, alter the electrical length of the antenna.

When the antenna element is of very large diameter, such as is often found in rotating beams, sufficient coupling to the "Grid Dipper" may not be obtained and some difficulty will be encountered in finding a reading. This condition may sometimes be relieved by jumping a foot or so of the antenna at the center with a small diameter wire and coupling to this wire.

If the antenna is to be normally used with its center open, close it with the shortest possible wire during measurement. This must be done also with the folded dipole. The short may later be removed, if required, when feeders are connected.

Tuned or resonant feeders, such as used in the Zepp antenna. Use instrument as grid-dip oscillator and check for desired resonance at the series or parallel tuned circuit on the transmitter end of the feeder. If resonance at the desired frequency is not obtainable, alterations may be made in the tuned circuit or the feeder length according to the actual resonant frequency found. Care must be exercised not to become confused by other resonance indications. It must be remembered that a Zepp is actually a long wire antenna partially doubled back on itself and resonance can therefore be noted at frequencies both higher and lower than the desired one.

Untuned or non-resonant feeders. After the antenna has been adjusted to the correct length, an untuned feed line may be connected employing some system of matching. Correct match may be obtained by making adjustment while employing a transmission impedance bridge or a standing-wave-ratio meter and using the "Grid Dipper" (set at antenna resonant frequency) as the signal generator.

The transmission bridge or the s-w-r meter should employ a meter of full scale sensitivity of 200 ua or less, for most accurate readings. Coupling to the "Grid Dipper" should be as loose as possible consistent with obtaining sufficient reading. If the coupling is too tight, the instrument frequency calibration may be slightly shifted.

The matching device should then be adjusted for as near unity standing-wave-ratio as

while ribbon in order to obtain most accurate results. Due to the distributed capacitance, especially in large coils, some slight error will result; however, if the value of the low inductance known capacitor is fairly high, the error will be negligible.

Relative Q of capacitors or inductances at a given frequency may be noted by observing the character of the dip as previously described.

Antenna. The instrument as first shipped as a coil. Coupling should be made at a low impedance or high voltage point as shown in Fig. 11. This point for a half-wave antenna, is at the center, and for longer waves is at points odd quarter wavelengths measured from either end. It will be measured that a half-wave antenna will not be a half-wave at exactly half its resonant frequency. This is because the end effects are found only at the antenna ends and will be absent at other points where the antenna is a full wave or more long. It is therefore always necessary to measure an antenna under the conditions needed relating to physical and electrical characteristics. It must be possible to check on a position or positions where the antenna is a half-wave or more long. It is important to check at a high impedance or high-voltage point. Coupling should be made as shown at Fig. 12. If the high impedance point is at one of the ends, the end effect will be altered due to the presence of the instrument and the resonant frequency of the antenna will slightly decrease. This must be taken into consideration when making measurement, i.e., the reading indicated will be slightly lower than the antenna resonance with "Grid Dipper" away from end. This difference will be about 1% and will be encountered only when checking at the ends.

In all cases it is helpful to keep in mind the physical length in feet vs. electrical length (half-wave, full-wave, etc.) as calculated approximately by formula. Unless coupled resonant circuits are detected when using the "Grid Dipper," As previously mentioned, these harmonics will not occur at exact multiples of a half-wave.

When measurement is made the lead should be disconnected from the antenna. Unless the

matched or terminated, two antenna resonances will not be indicated because unmatched feed-ers or incorrectly terminated feeders will present either a positive or negative resistance and will, therefore, alter the electrical length of the antenna.

If the antenna element is of very large diameter, such as is often found in rotating beam antennas, coupling to the "Grid Dipper" may not be easy and some difficulty will be encountered in finding a reading. This condition may sometimes be relieved by using a lead on one of the antenna's; the meter with a small diameter wire and coupling to this wire.

If the antenna is to be normally used with its center open, close it with the shortest possible wave during measurement. This must be done also with the folded dipole. The short may later be removed, if required, when feeders are connected.

Tuned or resonant feeders, such as used in the Zepp antenna. The instrument as shipped is designed to measure the impedance at the antenna end. It is not desirable, either, to have the meter at the feed point or the antenna end. It must be remembered that a Zepp is actually a long wire antenna partially doubled back on itself and resonance can therefore be noted at frequencies both higher and lower than the desired one.

Tuned or non-resonant feeders. After the antenna has been adjusted to the correct length, an antenna feed line may be connected employing some system of matching. Correct match may be obtained by means of a transmission line employing a transmission impedance bridge or a standing-wave ratio meter and using the "Grid Dipper" (set at antenna resonant frequency) as the signal generator.

The transmission bridge or the S-T meter should employ a meter of full scale sensitivity of 200 or less, for most accurate readings. Coupling to the "Grid Dipper" should be as loose as possible consistent with obtaining sufficient reading. If the coupling is too tight, the instrument frequency calibration may be slightly shifted.

The instrument should be set at the antenna end. The antenna should be at the antenna end.

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possible. If a satisfactorily low standing-wave-ratio is unobtainable, it is due to either a fault in the matching system or due to a shift in antenna resonance. The latter may be checked by slightly varying the "Grid Dipper" frequency until a lower s.w.r. is found or until a better s.w.r. meter null is indicated. The frequency at this point will be that of antenna resonance. If necessary, the antenna length may then be changed until the correct standing-wave-ratio is realized at the desired frequency. It may also be necessary to trim up the adjustment of the matching system.

Tuning the parasitic beam. Use the instrument as grid-dip oscillator and adjust driven element for resonance. The feeder should be disconnected and the parasitic elements should be set at their calculated correct length. If the driven element is open at the center, close it. After this element has been properly set, connect and match feeder as described in the foregoing paragraph (open antenna center if matching system so requires). The parasitic elements may then be adjusted using the "Grid Dipper" as the signal generator coupled to the feed line and by observing readings on a receiver (with an "S" meter) connected to a short antenna some distance away. Relative field readings in actual "S" units then may be obtained after each adjustment. As when matching feeder, coupling to the "Grid Dipper" should be as loose as possible. It is a good idea to occasionally check the actual frequency of the instrument on the receiver.

Following the tuning of the parasitic elements, the standing-wave-ratio should again be checked. It will, undoubtedly, increase, because tuning of the other elements will cause a change in antenna resonance. This will have to be altered accordingly, as described under "matching of non-resonant lines." Repetition of the preceding steps is advisable for putting on the finishing touches.

If the beam is located so that surrounding objects are likely to cause detuning as the beam is rotated (this may be checked during antenna and parasitic element tuning), it may be advisable to do the final retuning with the beam positioned either towards the direction in which it will be mostly used, or where the greatest degree of rotation has the least effect.

Needless to say, the transmitter may be used as the signal generator in place of the "Grid Dipper" during the above adjustments; however, the employment of the "Grid Dipper" for this purpose is more convenient, because the entire operation may be handled right on

the roof by one person, or wherever the beam is located. The use of the instrument also keeps the channel free from unnecessary QRM.

Quarter-wave shorted lines. Use as a grid-dip oscillator and couple for open wire lines as at Fig. 1G, and for coaxial lines as at Fig. 1H. When trimming lines for correct length, fittings to be used eventually for connections should be installed on the end of the line. The approximate frequency of the line may be determined by rough calculation. Other resonant points can be found, however. These will be at three times the fundamental quarter-wave, where the line is then three-quarter waves long, or five times the fundamental quarter-wave, etc.

Quarter-wave open lines. For open-wire lines, connect a short at one end and measure as for quarter-wave shorted line. Due to the length of the short, the actual electrical length of the line (used as an open line) will be slightly in error depending on the line spacing. The closer the spacing, the smaller the error.

For coax lines, place short on line and measure as quarter-wave shorted line. The short should be as direct and short as possible from inner conductor to shield in order to avoid errors. Fittings should also be included. Remove the short after measurements are completed.

Half-wave shorted lines. For open-wire lines, couple at center as shown at Fig. 1I. For coax line, measure for quarter-wave shorted line at half the calculated or desired frequency. Resonant frequency thus found must be then multiplied by 2 for a resulting half-wave shorted line.

Half-wave open lines. For open-wire lines, couple at center as shown at Fig. 1I. For coax line, short one end and measure for quarter-wave shorted line at half the calculated frequency. Resonant frequency thus found must be multiplied by 2 for the correct length of the line after short is removed; provided the short is made direct as mentioned above.

Check standing waves. Aside from employing the "Grid Dipper" as the signal generator in conjunction with a standing wave ratio meter, open-wire feed lines may be checked for the existence of standing waves by using the instrument as a diode detector. A flat line is indicated when the meter reading remains constant as the "probe" coil is moved along the line. Care must be used to maintain uniform

distance or coupling between coil and line. Since the "Grid Dipper" coil is protected by an insulated sleeve, the coil form may be held against the line for maintaining uniform coupling.

This method is the same as that using a neon bulb, crystal detector or other similar device.

Relative field-strength meter. Use the "Grid Dipper" as diode detector. Connect a short antenna to one of the coil posts through a 5-30 mmf capacitor. The instrument's frequency calibration will shift some, so the dial

will have to be rotated for maximum reading of the received signal. Actual frequency calibration is unimportant for this purpose. Sensitivity of the "Grid Dipper" as a field meter is not as great as that of some other devices, but it will, nevertheless, be helpful in many cases.

The "Grid Dipper" may be employed for a number of other measurements, principally when utilized as a signal generator. Its use as a grid-dip oscillator will be quite obvious and self suggestive for measurement of many other types of equipment and circuits. The applications herein described are those which will be generally most useful.

IV. POWER SUPPLY

The 90661-90651 is supplied complete with its own internal power supply. The unit will operate on 105 to 125 volts at 50 to 60 cycles per second. If it should become necessary to use the instrument where 115 volt, 60 cycle power is not readily available, it may be operated from a battery power supply.

Battery power should be connected to the terminal board, TB1, as indicated on the schematic circuit diagram, K 90651. The brown jumper between terminals 3 and 4 on TB 1b connects the oscillator tube heater to the 6.3 volt transformer winding. For battery operation, remove this jumper and connect positive 6 volts to terminal 4, the extreme left terminal. The heater battery supply needs to supply only 150 ma.

The red jumper between terminals 1 and 2 on TB 1a connects the internal B+ supply to the oscillator. For battery operations, remove the jumper and connect positive 67 to 135 volts to terminal 2, the terminal second from right.

The center terminal is ground and should have A-negative and B-negative connected to it. The cable connecting the battery power supply to the Grid-Dip Meter should be fed through the hole provided in the left side of the cover. This hole is normally covered with a plug button.

The FIL. and PLATE switches on the front panel control the battery supply as well as the a-c supply.

V. GROUND

The power cable on the 90661 Industrial Grid-Dip Meter is a three wire cable with a ground lead. The Grid-Dip Meter should be

connected to a point of zero potential (ground) whenever the unit is used in the vicinity of equipment on which high voltage is applied.

VI. MAINTENANCE

The entire unit is built on a single frame, therefore the cover on three sides may be removed simply by removing the four screws on the bottom.

If the unit does not operate, as indicated by lack of meter reading, check first to be sure a coil is plugged into the coil terminals, and

second check the fuse. If the fuse is defective check for short circuit in B+ or heater circuit before replacing fuse. Do not replace fuse with a fuse larger than 1½ amperes.

It is normal for the meter to read a very slight amount when the filament is turned on and the plate is turned off.

VII. LOW FREQUENCY USE

If it is desired to use the No. 90661 or No. 90651 at frequencies below 1.7 megacycles, the following additional coils may be procured:

No. 46702	925 to 2000 kc.
No. 46703	500 to 1050 kc.
No. 46704	325 to 600 kc.
No. 46705	220 to 350 kc.

At low frequencies, below about two megacycles, coupling is a little more difficult than

at higher frequencies due to the geometry of the coil.

The Grid-Dip-Meter coil should be held near an **unloaded** tuned circuit. The Grid Dip Meter coil should be approximately **coaxial** with the coil under test. **Slowly** tuning the Grid Dip Meter with one after another of the coils should locate a sharp dip at the resonant frequency of the tuned circuit under test. **Close coupling** and **careful alignment** of the Grid Dip Oscillator coil with the coil under test will show a sharp dip in meter reading at the resonant frequency.

VIII. COILS

Seven protected coils are supplied with the unit. The color-code on the coil base corres-

ponds with the color code on the calibrated scale.

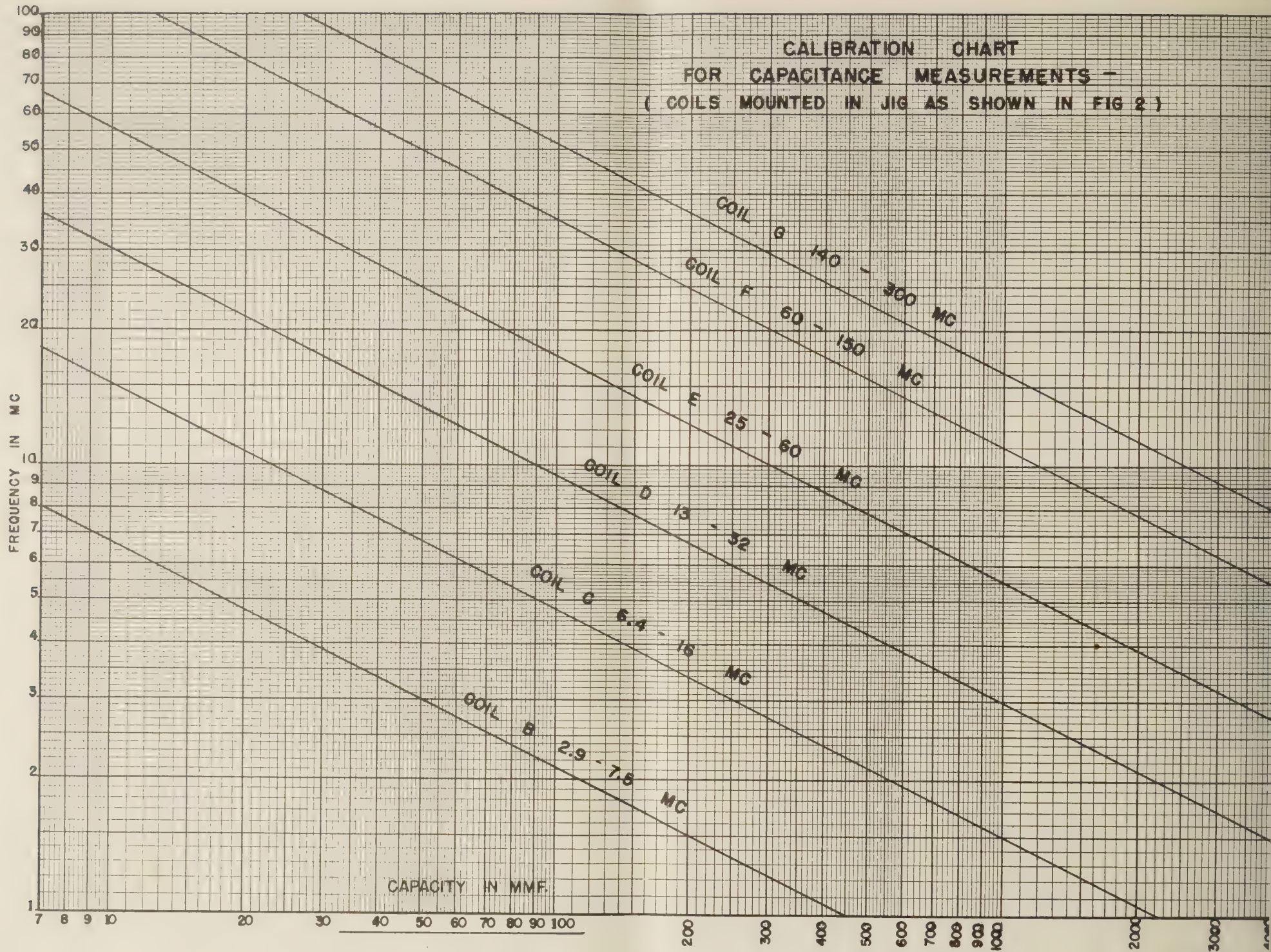
IX. TECHNICAL SUMMARY

Frequency Range: 1.7 to 300 megacycles in seven ranges with large over lap.

Size: 7 inches x $3\frac{3}{16}$ inches x $3\frac{3}{8}$ inches (less coils).

Weight: $3\frac{1}{2}$ pounds.

CALIBRATION CHART
FOR CAPACITANCE MEASUREMENTS -
(COILS MOUNTED IN JIG AS SHOWN IN FIG 2)



CALIBRATION OF 46702
LOW FREQUENCY INDUCTOR
FOR JAMES MILLEN #90651 OR #90661
GRID DIP METER

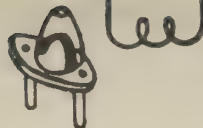
FREQUENCY IN KILOCYCLES

NO. 46702 1000 TO 2000 K.C.

JAMES MILLEN MFG. CO. INC.
9 JANUARY 1958

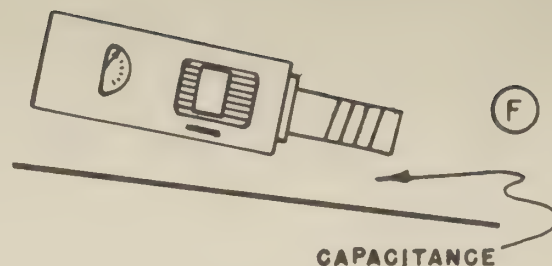
DIAL

0 2 4 6 8 10



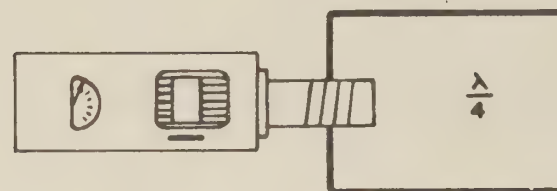
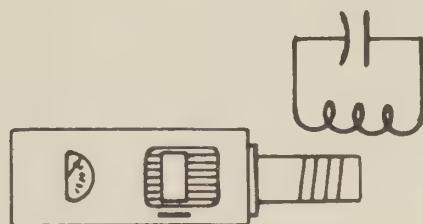
HIGH FREQUENCY
HAIRPIN COIL COUPLED
AT SIDE.

(A)



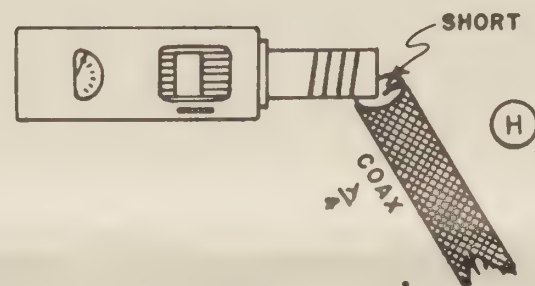
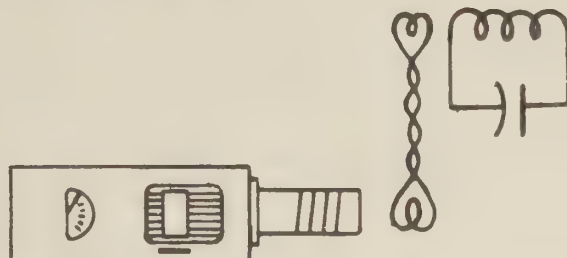
(F)

(B)



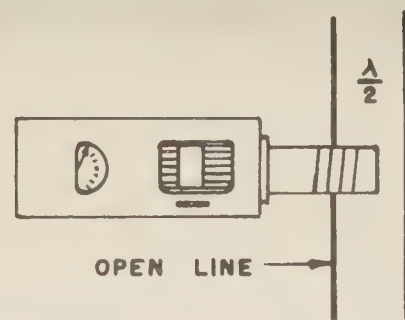
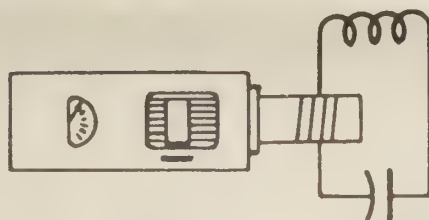
(G)

(C)



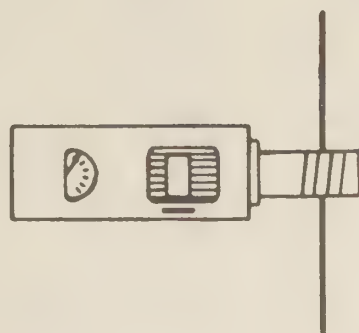
(H)

(D)



(I)

(E)



NOTE :

PROPER METHODS OF COUPLING THE
GRID - DIPPER TO CIRCUITS UNDER TEST,

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (I)			
FIRST MADE FOR			
DESIGNED BY		CHECKED BY <i>R.W.C.</i>	
DRAWN BY <i>H. GOTTERLY</i>		APPROVED	
JAMES MILLEN MFG. CO., INC.		K	DATE
MALDEN, MASS., U.S.A.			5 - 3 - 49

APPENDIX I

EQUATION

"A"

$$Q = \frac{Fr}{\Delta F}$$

EQUATION

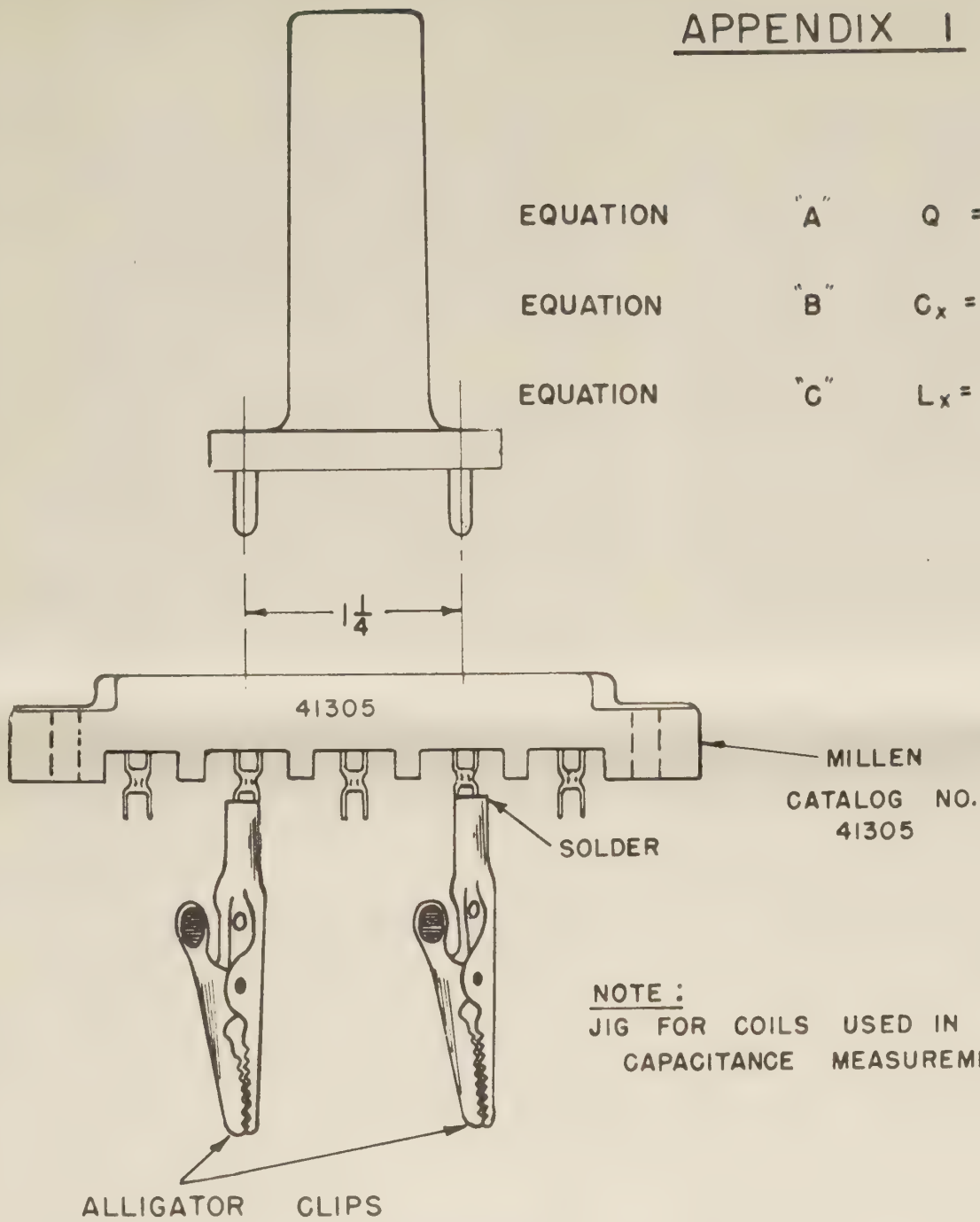
"B"

$$C_x = \frac{1}{4 \pi^2 F^2 L}$$

EQUATION

"C"

$$L_x = \frac{1}{4 \pi^2 F^2 C}$$

NOTE :

JIG FOR COILS USED IN
CAPACITANCE MEASUREMENTS

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (2)

FIRST MADE FOR

DESIGNED BY _____
DRAWN BY H. GOTTERLY

CHECKED BY R.W.C.
APPROVED _____

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K

DATE
5 - 3 - 49

GRID-DIP METER FOR RAPID TV CHECKS

Because of its light weight and small size, the versatile grid-dip meter is a useful instrument for servicing or preliminary checking of tv receivers in the home. In many cases, it may be used by itself to make quick checks that would ordinarily require the use of a sweep generator, a marker generator, and an oscilloscope.

Description

The particular instrument used in this series of experiments was the Millen Grid-Dip Meter No. 90651, which is typical of its kind. It includes a tuning dial, a meter, an ON-OFF switch for plate voltage, a set of plug-in coils for use over different ranges, and a coupling probe. This version of the grid-dip meter uses seven plug-in coils for the seven corresponding ranges calibrated on the tuning dial; it may be adjusted to any frequency from 1.7 to 300 mc. The probe consists of a length of shielded wire terminating in a single loop at one end and a double loop at the other. The two-turn loop is fitted over the plug-in coil chosen for use. The single-turn loop is injected into circuits under examination.

Applications

The meter was used successfully for checking alignment and operation of the oscillator and mixer circuits in the front end of a typical tv receiver; for checking individual alignment of i-f coils, traps, and other adjustable resonant circuits; and for injecting markers on response curves. Specific instances of the grid-dipper's use are given here to illustrate the techniques involved.

Testing TV Local Oscillators

Where a raster is present on the picture-tube screen of a receiver, but a picture cannot be obtained on any channel, the signal circuits (r-f, i-f, and video-amplifier sections) are suspect. If the video-amplifier and i-f sections are found to be normal, examination is directed to the front end. It may be that the local oscillator is inoperative or adjusted to the wrong frequency.

To check this, the receiver is set up, with a sweep generator and oscilloscope, for obtaining the over-all (r-f and i-f) response curve in accordance with the set manufacturer's instructions. In this case, the scope was connected across the video-detector load resistor, and the sweep generator was connected to the receiver's antenna-input terminals. A 4.5-volt battery provided override bias in the agc line. Its negative lead was connected to the line; the positive pole was grounded to the chassis. Both the receiver and the generator were adjusted to the same channel. In this case, the receiver was tuned to channel 6 and the generator was accordingly adjusted to sweep 6 mc across the channel-6 bandwidth (82-88 mc). A straight-line horizontal trace appeared on the scope when an attempt was made to obtain an over-all response curve.

The grid-dip oscillator was then set up as a substitute for the local oscillator in the front end, as follows: The video i.f. for this receiver is given as 21.75 mc. The video carrier for channel 6 is 83.25 mc. The correct frequency for the local oscillator, when tuned to channel 6, is therefore the sum of these, or 105 mc. With the appropriate plug-in coil in place, the grid-dipper's tuning dial was set to 105 mc. With the two-turn loop of the probe placed over the plug-in coil, a substitute oscillator signal was injected into the front end by placing the single-turn loop directly over the oscillator tube. With this arrangement, the response curve shown in Fig. 1 was obtained. Markers were placed on the curve 5 mc apart to show bandwidth. When the grid-dip oscillator was turned off, the response curve disappeared, proving that the trouble existed in the oscillator circuit.

With the receiver's local oscillator restored to normal functioning, the response curve obtained was identical to that shown in Fig. 1. It is interesting to note that the same check can be made in the home, with an active transmission and the picture tube substituted for the sweep generator and oscilloscope. With the grid-



Fig. 1

dipper substituted for an inoperative local oscillator in the arrangement already described, and the receiver tuned to an operating channel, useful picture and sound is reproduced. Picture and sound quality should not always be expected to match that obtainable when the receiver is operating properly. However, the fact that any signal can be intelligibly reproduced by the injection of a substitute oscillator signal, while none appears when the grid-dipper is turned off, is sufficient to localize the fault definitely.

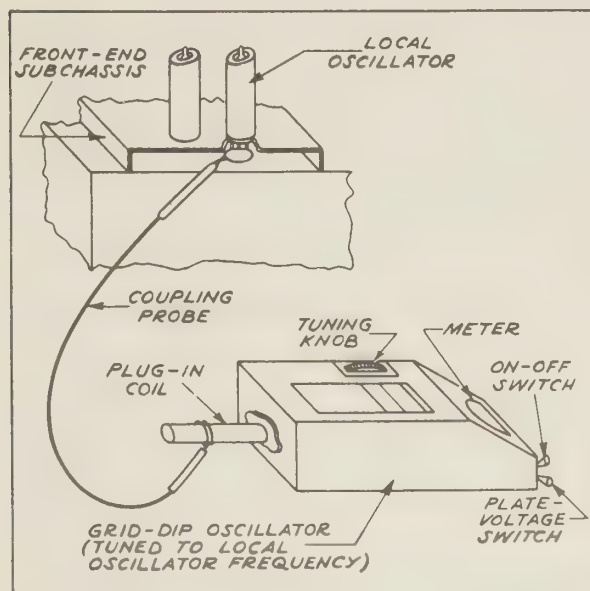


Fig. 2

This technique for substituting the local-oscillator signal was tried out on all standard tv channels. It was found to work successfully, as described, over the low band (channels 2 to 6). To obtain sufficient output for channels 7 to 13, the single-turn coupling link had to be removed from the oscillator tube itself and placed near components in the tube's circuit, underneath the front-end subchassis. This arrangement is illustrated in Fig. 2.

An alternate method may be used to check the local oscillator without the use of sweep generator or oscilloscope. In this technique, the grid dipper is also connected as shown in Fig. 2. The plate-voltage switch, however, is thrown to the OFF position, changing the instrument from an oscillator to an absorption device. The receiver is tuned to the channel to be tested and the dipper is set to the appropriate oscillator frequency. If the oscillator is operating and in proper adjustment, it will radiate energy into the coupling link of the grid-dipper. This will be shown by deflection on the instrument's meter. If there is no such indication, either the local oscillator is not functioning or it is operating at the wrong frequency.

Local-Oscillator Alignment

If the latter condition is the one that exists, the local oscillator can be retuned with a fair degree of accuracy with the aid of the grid-dipper. The grid-dipper must remain tuned to the correct oscillator frequency. The local-oscillator coil is then aligned for a peak on the grid-dip meter. In some cases, this peak will be rather broad, maintaining itself over a considerable range of adjustment of the oscillator coil. This can be counteracted by reducing coupling from the oscillator. The coupling link is moved away from the oscillator components until a sharp peak can be tuned on the oscillator coil.

Checking Alignment of I-F Coils

When a receiver is suspected of having a misaligned i-f strip, the grid-dipper is also useful for a reasonably close check of individual coils. The single-turn coupling loop is placed over the coil to be checked in the arrangement illustrated in Fig. 3. The test is conducted with the grid-dipper operated as an

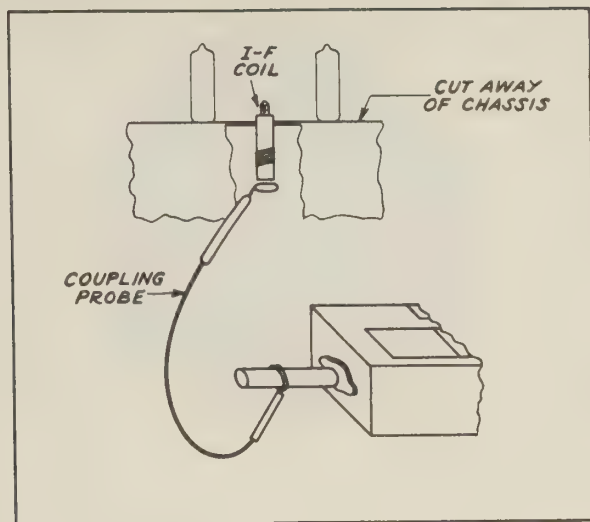


Fig. 3

oscillator (the plate-voltage switch in the ON position) and with receiver power turned off. A plug-in coil is chosen that will permit the grid-dip oscillator to be tuned through the range of frequencies over which the i-f coils should be normally adjusted. The grid-dipper tuning control is then rotated for *minimum* indication on the grid-dip meter. At this point, the reading on the tuning dial is the actual resonant frequency of the i-f coil assembly.

The i-f coil itself may then be aligned to its approximate frequency, if it is found to be mistuned. This is done by setting the grid-dip oscillator's tuning control to the desired alignment frequency and adjusting the tuning slug or trimmer on the i-f coil assembly for a dip, or minimum indication, on the grid-dip meter. A similar procedure may be employed to adjust sound traps or other traps in the video-signal portions of the receiver.

Checking Video-Amplifier Bandwidth

The grid-dipper, operated as an oscillator, also makes a handy marker generator. As such, it may be used to run a marker across a response curve to check correct placement of alignment points along the curve or to determine bandwidth.

It was tested in this capacity with a typical video-amplifier response curve, obtained with a sweep generator adjusted to sweep 0 to 10

mc, a crystal-detector probe, and an oscilloscope. The typical arrangement of these instruments is given in greater detail in CIRCUIT GUIDES III-1 and III-2. The response curve thus obtained is shown in Fig. 4.

The plug-in coil that provided the lowest range was then inserted into the grid dipper, which was tuned to 4 mc. Marker coupling was achieved by holding the probe's coupling link near components in the video-amplifier circuit. The curve thus marked appears in Fig. 5. Marker amplitude could be controlled easily by moving the probe closer to or away from the circuit components. When the grid-dipper's tuning dial was run down to 2 mc, the marker moved to the position shown in Fig. 6.

Although the grid-dip meter is a handy and valuable instrument, its accuracy, although

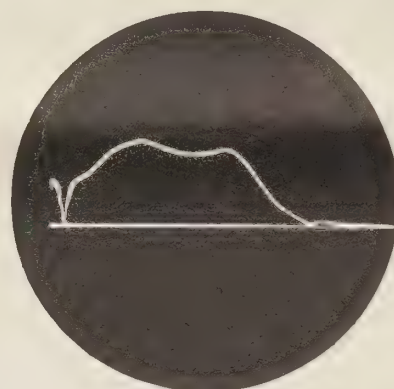


Fig. 4

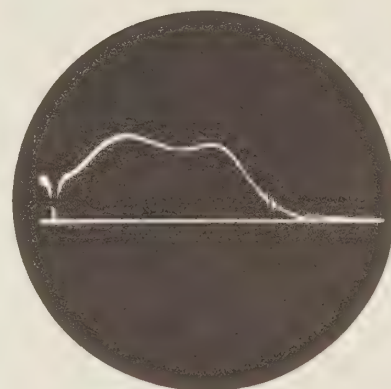


Fig. 5

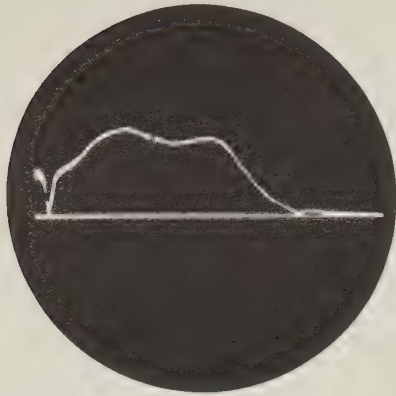


Fig. 6

very good, does not compare with that of a crystal-calibrated generator. The tests described here will give an approximate check of frequency adjustment and alignment; where greater accuracy is required, standard alignment procedures must be followed. However, since the grid-dipper may be used to determine whether such alignment is or is not necessary, even in such cases there is much saving of time in the needless setting up of test equipment for alignment where the set-up is not needed.

INSTRUCTIONS

for

GRID-DIP METER

Cat. No. 90651 - Serial No.

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U. S. A.

No. 90672 ANTENNA BRIDGE

1. DESCRIPTION

The 90672 Antenna Bridge is an accurate and sensitive bridge for measuring impedance in the range of 5 to 500 ohms for unbalanced input and 20 to 2000 ohms for balanced input (using a 4:1 balun) at radio frequencies up to 200 mc. The variable element in this new bridge is an especially designed differential capacitor of high accuracy and permanency of

of calibration over a wide range of frequencies. The bridge is entirely different in design from others designed for this type service, in as much as it employs no variable resistors of any sort. The 90672 was designed to use a grid dip meter, such as the Millen 90651 or its industrial counterparts the 90661 or the 90662, as a source of RF signal.

2. APPLICATION

The bridge may be used to measure the antenna radiation resistance, antenna resonance, transmission line standing wave ratio, receiver input impedance, and many other radio frequency impedances. By means of the Antenna Bridge, the transmitter matching unit may be adjusted to provide the minimum standing wave ratio on the transmission line at all frequencies. The RF power from the grid dip meter is coupled to the pick up loop on the bridge and the frequency of the RF power is set to the desired frequency. The knob on the bridge is adjusted for minimum meter reading. The unknown impedance in ohms is read directly from the bridge dial scale. **DO NOT UNDER ANY CIRCUMSTANCES LEAVE THE BRIDGE IN THE CIRCUIT WHILE THE TRANSMITTER IS IN USE.** The bridge is a measuring instrument not a device for monitoring the performance of transmitters.

The most important part of an amateur radio station, aside from the operator, is the radiating system. The radiating system consists of the actual radiator or the antenna, the device or means for matching the antenna to the transmission line, the transmission line, and the device for matching the transmission line to the transmitter. Rated loading, as indicated by the power input to the transmitter, indicates only that the radiation system is absorbing power from the amplifier. This does not indicate that the power is getting to the actual antenna **unless** an antenna bridge has been used to adjust properly the impedance matching devices at both ends of the transmission line.

The impedance of the antenna varies along its length. A half wave antenna is an electrical half wave length long only at one frequency and has a high impedance at the ends and a low impedance at the center. Since the transmitter and the antenna are separated,

an RF transmission line must be used to connect the antenna to the transmitter. Unless the output end of the transmission line is terminated in an impedance equal to the characteristic impedance of the line, power is reflected back along the line from the end. In order to transfer the power from the transmission line to the antenna, it is necessary to match the characteristic impedance of the transmission line to the resistance of the antenna at the point where the line is connected to the antenna. The Antenna Bridge may be used to measure the impedance of the antenna at the point where the transmission line is connected and it may also be used to adjust the matching of the line to the antenna. See section 6 paragraph B for instructions on adjusting the resonant frequency of an antenna, using the Bridge. A balun will be required when the Bridge is used to measure a balanced line.

A transmission line must be terminated in its characteristic impedance at the input as well as its output end. The impedance of the final amplifier in the transmitter will not be equal to the impedance of the transmission line, so an antenna matching device (sometimes erroneously referred to merely as a loading unit) is required to make the necessary impedance transformation. In many cases the transmission line is matched to the antenna only approximately and the antenna matching unit at the transmitter end of the line is adjusted to get the best over all compensation for securing the minimum standing wave ratio. It is absolutely essential that an antenna bridge be used for proper adjustment of the antenna matching network. The antenna matching unit's purpose is to match the over-all impedance of the antenna and transmission line to the transmitter and in some cases to compensate for the reactance left in the transmission line.

3. OPERATING PRECAUTIONS

CAUTION: Reduce the coupling from the grid dip meter before removing the unknown impedance from the bridge, otherwise the very sensitive null indicator will be damaged. Never

use as a power source any pieces of equipment with greater power than a grid dip meter. Never use a transmitter as the power source. See section 5.

4. STANDING WAVE RATIO

Standing waves are caused by energy which is reflected from the terminated end of the transmission line that is not terminated in its characteristic impedance. The reflected energy obviously is not radiated by the transmitting antenna in the case of a transmitter nor is it delivered to the receiver in the case of a receiving antenna. The standing wave ratio is the ratio of the maximum current to the minimum current in a transmission line. When no standing waves are present the maximum and minimum currents are equal and the ratio is one, which means the line is terminated in a pure resistance equal to the characteristic impedance of the line. The standing wave ratio is a measure of the mismatch between the transmission line and its termination.

The power losses in a transmission line are proportional to the square of the current. If the standing wave ratio is too much greater than one the loss increases quite rapidly.

Standing waves on a transmission line to a receiver are caused by reflection at the input terminal of the receiver. The energy is dissipated as described above. In the receiving system it is also necessary to match the re-

ceiving antenna to the transmission line for only then will a maximum signal be delivered at the input of the receiver.

The standing wave ratio is the ratio of the load impedance to the line impedance. To measure antenna resistance, couple the Bridge to the antenna by means of a transmission line which is some multiple of a half wave length long at the desired frequency and resonate the antenna at the desired frequency. The method of accomplishing this is described further in section 6. Make the line a half or 1 wave length long to avoid confusion with multiple nulls.

When a "T" match is used the antenna must be re-resonated with each change of the "T". After a proper null is obtained the transmission line length may be changed from $\frac{1}{8}$ to $\frac{1}{4}$ wave length and the impedance as indicated on the bridge should not change. If the impedance indicated on the bridge is changed when the line length is changed, either the antenna is not resonant at the frequency of measurement or the matching is not complete.

5. RF SOURCE

The RF input for the 90672 Antenna Bridge can be any convenient source of power. The Millen 90651 Grid Dip Meter is the recommended source of power. Since a 50 micro-ampere meter is used as a null indicator on the Bridge, do not use too much RF input. The sensitivity of this bridge is very good, consequently loose coupling to a grid dip meter gives all the sensitivity required until the null is reached. At this point tighter coupling to the grid dip meter may be used but at no time is a power source with more output than the grid dip meter required or permissible.

Three RF pick-up loops are supplied with the Antenna Bridge. The large black coupling coil is resonant in the bridge at approximately 5.2 to 8.8 mc. depending upon the impedance setting. At 500 ohms the large coil is resonant at about 5.2 mc., at 50 ohms it is resonant at about 6.2 mc. and at 5 ohms it is resonant at about 8.8 mc. It should be used for all measurements below 12mc. The large white coupling coil is resonant in the bridge at about 15 mc. at 500 ohms, about 19.1 mc. at 50 ohms,

and about 30.5 mc. at 5 ohms and should be used for all measurements between about 12 and 40 mc. The smallest coupling loop is resonant at about 32 mc. at 500 ohms, about 39 mc. at 50 ohms, and about 84 mc. at 5 ohms and should be used for all measurements above 40 mc. The largest coupling coil and the intermediate coupling coil result in about the same coupling at about 12 mc. When the bridge is set at 50 ohms the intermediate coupling coil and the smallest coil result in about the same coupling at about 40 mc. Since the greatest coupling occurs with the coupling coil at its highest impedance, the coupling coil which is most nearly resonant at the desired frequency is the coil which should be used. It is, of course, possible to make a coupling coil which will be resonant at the particular frequency at which the measurement is desired. However, experience has indicated that the 3 coils supplied with the Antenna Bridge adequately cover the range and that other coils will be required only under certain very special circumstances.

6. DETAILED APPLICATION INSTRUCTIONS

A. GENERAL USE

1. Couple a voltage of the desired frequency to the Bridge. Since a 50 micro-ampere meter is used as a null indicator in the Bridge, the measurement should begin with loose coupling to prevent the possibility of damage to the instrument.

2. Adjust the coupling by moving either the Bridge or the RF source so that the meter indicates on scale somewhere in the vicinity of 40 micro-amperes, off null.

3. Connect the unknown impedance to the antenna jack. Use the proper coupling plug and in no case use lengthly haywire.

4. Adjust dial for minimum meter reading.

5. Read the value of the unknown impedance in ohms directly from the dial scale.

B. RESONANCE

A point which should not be overlooked in measuring antenna impedance is that antenna resonance must be obtained before the minimum standing wave ratio can be achieved. The antenna is resonant at only one frequency and thus at only this frequency is the impedance a pure resistance. Consequently the antenna must be made resonant at the desired frequency before any attempt is made to match the transmission line to the antenna. Any measurement made off resonance will be misleading.

The Antenna Bridge can be used both to determine resonance and to adjust to minimum standing wave ratio. When the antenna is adjusted for minimum meter reading the impedance at which the standing wave ratio is a minimum has been determined. However, if the meter reading is not zero the antenna is not resonant. By a step by step adjustment of the input frequency, one can find the frequency at which the antenna is resonant. If the antenna is not resonant at the desired frequency it will be impossible to obtain a complete null. The Antenna Bridge can be used easily for obtaining both resonance and minimum standing wave ratio. Furthermore, since the resonant frequency is known, the type of adjustments necessary to bring the antenna to resonance at the desired frequency is known; and since the impedance is known, the adjustments required to minimize the standing wave ratio are known. The bridge indicates when the proper adjustment has been made and also indicates which direction to go to obtain the desired result.

C. UNBALANCED LINES

The Antenna Bridge as it stands can be used directly with unbalanced lines. The shielded portion of the line will be grounded directly to the case of the Antenna Bridge and thus hand capacity and stray capacitances will not affect the measurement. Measurement should be made exactly as outlined above in paragraph A.

D. BALANCED LINES

A balanced line may be measured using the Antenna Bridge by the use of a balun coil, a bazooka transformation for transforming 300 ohm balanced twin line to 75 ohm unbalanced line, or in most cases it will be accomplished by the use of the antenna matching network. When either the bazooka transformation or the balun coils are used, the Bridge is operated exactly as if the line were a quarter of its actual impedance. Both the bazooka and the balun result in a 4:1 impedance ratio. Thus a 300 ohms transmission line properly transformed will read 75 ohms on the bridge, or a 600 ohm open line will read 150 ohms on the bridge. Thus the bridge scale of 5 to 500 ohms becomes 20 to 2000 ohms. This coincides with the usual higher impedances of balanced lines. The use of a balun maintains balance during measurement and thus obviates the wild errors usually encountered when one tries to measure any balanced line impedance without first converting it to a single ended load. The balun coils for the amateur bands are available as additional Bridge accessories.

E. ANTENNA MATCHING UNITS

For proper adjustment of an antenna matching unit; the Bridge is substituted for the transmitter. The coaxial cable from the antenna matching unit, which is usually connected to the transmitter, should be connected to the antenna jack on the Bridge. A grid dip meter or other low power source of radio frequency voltage should be coupled to the Bridge coupling coil. **DO NOT UNDER ANY CIRCUMSTANCES LEAVE THE BRIDGE IN THE CIRCUIT WHILE THE TRANSMITTER IS USED.** It is desirable after having adjusted the antenna to resonance at the desired frequency as outlined above, to make a table of the dial readings of the antenna matching network which result in minimum standing wave ratio over the frequency range for which it is intended to use the radiating system. When changing frequency it is necessary only to refer to the table of dial readings on the antenna matching network to assure minimum standing wave ratio.

F. QUARTER WAVE LINES

A quarter wave line left open circuit at the output end appears at the input as a short circuit. Lines odd numbers of quarter waves long which are open at the end also appear shorted at the input. With the Antenna Bridge set at the horizontal line at the 5 ohm end of the scale, find the lowest frequency at which an approximate null occurs. This is the frequency at which the line is a quarter wave length long. At approximately three times this frequency another null will be obtained and this is the frequency at which the line is three-quarter wave length long. The quarter wave frequency in mc. is equal to 246 times the velocity of propagation divided by the length of the line in feet. Thus with the length of line known, the frequency at which the line is a quarter wave length long determined by the means of the Bridge, the velocity of propagation can be determined. A quarter wave line may be used to measure the impedance connected at its end. The impedance measured at the input will be equal to the characteristic impedance of the line squared divided by the load impedance. Thus by measuring the input impedance and the characteristic impedance of the line, it is possible to determine the impedance at the far end of the line. In making any of these impedance measurement using twin lead transmission line be certain that the transmission line is set in the open and kept away from ground, etc.

G. HALF WAVE LINES

A half wave length line short circuited at the output end will appear short circuited at the input end. In other words a half wave line will repeat its termination impedance. Set the Antenna Bridge dial to the horizontal line at the 5 ohm end of the dial scale and find the lowest frequency at which an approximate null is obtained. This is the frequency at which the line is a half wave length long. Any multiple of a half wave length will also produce a null. Half wave lines will repeat at the input end the impedance connected to the output end. Thus a half wave line may be used to determine the impedance in which it is terminated merely by measuring the input impedance.

H. CHARACTERISTIC IMPEDANCE

The characteristic impedance or the surge impedance of a transmission line may be measured by leaving the output end open circuited. Set the Antenna Bridge to the horizontal line at the 5 ohm end of the dial scale, find the lowest frequency at which the transmission line is a quarter wave length long. Now terminate the ends of the transmission line in a resistor. For 50 ohm line use about 30 or 100

ohms. For 100 ohm line use 50 or 200 ohms. For 300 ohm line use about 200 or 600 ohms. Find the new Bridge null, still leaving the rf source frequency at the quarter wave frequency. The characteristic impedance of the line will equal the square root of the Bridge reading, sometimes called the "inverted impedance," times the square root of the load resistance. It may be necessary to measure the load resistance at the frequency in use. It is possible that the "inverted impedance" is not within the 5 to 500 ohm range of the Antenna Bridge. If this should be the case, try a somewhat different terminating resistance until the "inverted impedance" is within the range of the Antenna Bridge.

I. ANTENNA RESONANCE AND RESISTANCE

Since a grid dip meter is generally available as a power source for the Antenna Bridge, antenna resonance is often determined easiest by means of the grid dip meter. However, in many cases where the antenna Q is low, or when the element diameter is large, it is difficult to use the grid dip meter to find antenna resonance and in many cases it is physically impossible to reach the proper point in the antenna without changing the physical position of the antenna. It is often hard to couple to a long wire at low frequencies, thus in many cases it is convenient to determine the antenna resonant frequency by means of the Antenna Bridge. Paragraphs J through O discuss measurements on particular types of antennas.

J. HALF WAVE DIPOLES

The easiest way of determining the resonance of a dipole antenna is to use a half wave transmission line between the antenna and the Antenna Bridge. The transmission line should be a half wave length long at the resonant frequency of the antenna. This is not as ambiguous as it sounds on the surface, because the frequency of the antenna is known approximately because the physical length in the standard formula will give the approximate frequency. The transmission line should be cut to a half wave at this calculated frequency. Cut the line slightly long so that successive approximations may be made so that a precise measurement may be made.

It is often desirable to cut an antenna to a particular resonant frequency rather than to measure the resonant frequency of an existing antenna. In this case, the transmission line should be made a half wave length long at the desired frequency and the antenna pruned to resonance. One precaution should be observed: The half wave length line **must** be at right angles to the antenna for at least a quar-

ter wave length in order to eliminate any coupling between the antenna and the transmission line. Failure to observe this precaution will result in erroneous answers. At high frequencies, it may be desirable to use a transmission line which is some multiple of a half wave length long. The impedance of the transmission line is not important, since it is being used only as an impedance "repeater" rather than to match the antenna.

If a balun is available, and if the frequency of measurement is lower than about 50 mc., the bridge may be used directly at the center of the antenna. Since the center impedance of a dipole is about 72 ohms, set at the Bridge dial to about $72/4$ equals 18 ohms and adjust the source frequency and Bridge dial for null. Here again, do not be too alarmed if the measurement does not coincide with previous impressions. The impedance should be dependent on the height of the antenna above ground. It can be determined whether the positions of the Antenna Bridge and the operator near the center of the antenna result in erroneous readings, by noticing whether or not the meter null changes when the operator moves away from the antenna. If position errors exist it will be necessary to resort to a half wave transmission line to measure as outlined in paragraph J above. At frequencies above 50 mc., the presence of the bridge and the operator at the center of the antenna will probably result in errors which will not occur when the bridge and the operator are removed from the center of the antenna. If a balanced transmission line, such as open line or twin line is used between the antenna and the Bridge, line unbalance to ground may be reduced by twisting the line every couple of feet or so. If a different reading is obtained when the line connection to the balun is reversed, unbalanced line to the ground capacity is indicated and should be corrected by twisting the transmission line.

K. FOLDED DIPOLES

The Bridge balun or the half wave line should be connected to the center of one side of the folded dipole (the point at which the transmission line is usually connected). The radiation resistance of the folded dipole is usually between 150 and 300 ohms or so. If the folded dipole is made of twin line it has a velocity of propagation such that the quarter period of the quarter wave length line is about 86% of the over all natural quarter period. Two impedances will be indicated on the Bridge. The correct indication is the one between 150 and 300 ohms, and the incorrect indication will be around 500 ohms. Consequently, the correct Bridge reading is the one that occurs at the highest frequency. This type of antenna results in narrow band pass. It is possible to

use the Antenna Bridge to compensate for the velocity of propagation and thus broaden the frequency response of a twin lead dipole to equal the band pass of an open wire dipole. One method of compensation is to place in series with the shorted ends a capacity of about 7 mmf per meter of wave length and tune each quarter wave section to the over all natural frequency. Another is to place short circuits at 86% of the normal distance from the center to each end. Another method is to cut the line of the folded dipole so that it is 492 times the velocity of propagation divided by the frequency in mc. feet long. A transmission line of twin lead should be cut to a half wave length at the desired frequency as outlined above in paragraph G. Short circuits should be placed at ends of the antenna. Open one side of the antenna and connect the Bridge balun or the half wave transmission line "repeater". Add a wire to each end of the folded dipole. Clip the wires back until antenna resonance is indicated at the desired frequency. The frequency response of an antenna made in this manner will approximate that of an open wire folded dipole.

L. HARMONIC ANTENNAS

To measure antennas any multiple of a half wave length long, connect the balun or the half wave transmission line "repeater" at any high current point.

M. QUARTER WAVE VERTICLE AND GROUND PLANE ANTENNAS

The impedance measured at the bottom of a quarter wave antenna is of the order of 35 ohms. The Bridge should be connected between the bottom of the antenna and the ground plane. If the transmission line impedance is higher than the end impedance of the vertical antenna, which is the usual case, the feed point impedance may be increased by increasing the angle between the radiator and the ground plane radials. Use the Antenna Bridge to determine the proper angle of the ground plane radials. The limit that can be achieved is about 70 ohms at which point the angle between the antenna and the ground plane radials is 180° and the antenna is a coaxial antenna.

N. MOBILE ANTENNAS

The bottom impedance of a quarter wave radiator placed on a car will be about 45 ohms. This impedance can be measured exactly as described in paragraph M above. For base loaded or center loaded antennas, the impedance will be 20 to 35 ohms. In order to measure, the base loading should be connected between the base of the antenna and the Antenna Bridge,

and the Antenna Bridge should be connected between the base loading and the ground plane of the car. Use the Antenna Bridge to determine what L and C are required for base loading, in order to match the antenna to 50 to 70 ohm transmission line.

O. PARASITIC BEAMS

The bridge should be connected by means of a balun or a half wave transmission line "repeater" to the center of the driven element. The impedance at this point will probably lie between 5 and 100 ohms. More than one null will be obtained due to the reflections from other elements, however, a properly tuned beam will have only one **complete** null at the true resonant frequency. Adjust the length of the driven element to resonance as described in paragraph I. The reflectors should then be cut to 5% longer than the driven element and directors should be cut about 5% shorter than the driven element. It is, of course, possible to tune the reflectors and directors but the improvement in the performance is seldom worth the additional effort.

P. ADJUSTING Q BARS

Q bars are used as a quarter wave trans-

former to match the antenna resistance to the line characteristic impedance. Connect the end of the bars to the Bridge balun or half wave transmission line "repeater" and the other end to the antenna. Adjust the spacing for the desired impedance. However, before the Q bars can be adjusted, the antenna must be resonant as determined in paragraph I and the Q bars must be a quarter wave length long.

Q. RECEIVER INPUT IMPEDANCE

If the receiver input is unbalanced, connect the bridge directly to the receiver input. If the receiver input is balanced, connect the receiver input to the Bridge balun. The input circuit of the receiver must be resonant in order to measure the input resistance. Over coupling between the antenna coupling coil and the first tuned circuit is a common condition and will be indicated by two bridge measurements, one of which will be in the vicinity of 5 to 20 ohms and the other 50 to 1500 ohms. Too loose coupling between the antenna coupling coil and the first tuned circuit is indicated by an incomplete null which results because the input is reactive.

The receiver input impedance may be matched by a network such as the Millen No. 92101 Antenna Matching Preamplifier.

7. TECHNICAL SUMMARY

POWER INPUT

No D.C. or 60 cycle power required.

A small fraction of a watt of rf power is required. It is suggested that a Millen 90651 Grid Dip Meter be used to supply this power.

IMPEDANCE RANGE

Unbalanced—5 ohms to 500 ohms

Balanced—20 ohms to 2000 ohms using balun not supplied with Bridge.

ACCESSORIES (Not included)

Millen 90651 Grid Dip Meter.

Baluns for the amateur bands.

PHYSICAL DIMENSIONS

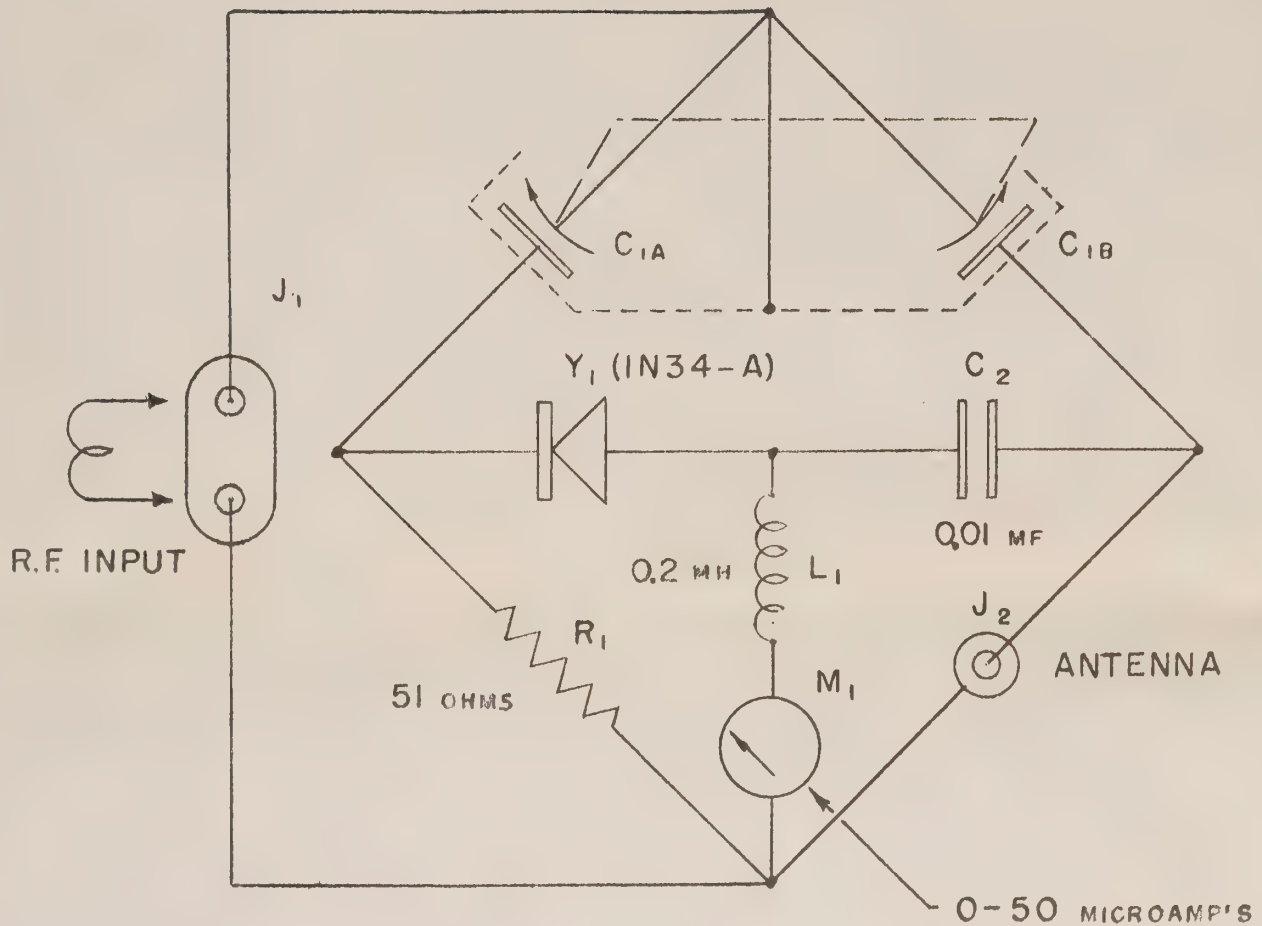
Length— $5\frac{5}{8}$ inches.

Width— $3\frac{1}{8}$ inches, plus rf connector.

Height— $3\frac{7}{8}$ inches, including knob.

Weight— $1\frac{5}{8}$ pounds.

R.W.C. 9/2/55



ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

			ANTENNA BRIDGE		
			FIRST MADE FOR		
	○		DESIGNED BY <u>R.W.C.</u>	CHECKED BY <u>R.W.C.</u>	
	○		DRAWN BY <u>R.KAROSAS</u>	APPROVED	
	○		JAMES MILLEN MFG. CO., INC. MALDEN, MASS., U.S.A.		DATE 8-23-55
			K 90672		

Instructions for

INSTRUCTIONS

for

ANTENNA BRIDGE

Cat. No. 90672 - Serial No.....

JAMES MILLEN MFG. CO., INC.

MALDEN, MASS., U. S. A.

No. 90672 ANTENNA BRIDGE

1. DESCRIPTION

The 90672 Antenna Bridge is an accurate and sensitive bridge for measuring impedance in the range of 5 to 500 ohms for unbalanced input and 20 to 2000 ohms for balanced input (using a 4:1 balun) at radio frequencies up to 200 mc. The variable element in this new bridge is an especially designed differential capacitor of high accuracy and permanency of

of calibration over a wide range of frequencies. The bridge is entirely different in design from others designed for this type service, in as much as it employs no variable resistors of any sort. The 90672 was designed to use a grid dip meter, such as the Millen 90651 or its industrial counterparts the 90661 or the 90662, as a source of RF signal.

2. APPLICATION

The bridge may be used to measure the antenna radiation resistance, antenna resonance, transmission line standing wave ratio, receiver input impedance, and many other radio frequency impedances. By means of the Antenna Bridge, the transmitter matching unit may be adjusted to provide the minimum standing wave ratio on the transmission line at all frequencies. The RF power from the grid dip meter is coupled to the pick up loop on the bridge and the frequency of the RF power is set to the desired frequency. The knob on the bridge is adjusted for minimum meter reading. The unknown impedance in ohms is read directly from the bridge dial scale. **DO NOT UNDER ANY CIRCUMSTANCES LEAVE THE BRIDGE IN THE CIRCUIT WHILE THE TRANSMITTER IS IN USE.** The bridge is a measuring instrument not a device for monitoring the performance of transmitters.

The most important part of an amateur radio station, aside from the operator, is the radiating system. The radiating system consists of the actual radiator or the antenna, the device or means for matching the antenna to the transmission line, the transmission line, and the device for matching the transmission line to the transmitter. Rated loading, as indicated by the power input to the transmitter, indicates only that the radiation system is absorbing power from the amplifier. This does not indicate that the power is getting to the actual antenna unless an antenna bridge has been used to adjust properly the impedance matching devices at both ends of the transmission line.

The impedance of the antenna varies along its length. A half wave antenna is an electrical half wave length long only at one frequency and has a high impedance at the ends and a low impedance at the center. Since the transmitter and the antenna are separated,

an RF transmission line must be used to connect the antenna to the transmitter. Unless the output end of the transmission line is terminated in an impedance equal to the characteristic impedance of the line, power is reflected back along the line from the end. In order to transfer the power from the transmission line to the antenna, it is necessary to match the characteristic impedance of the transmission line to the resistance of the antenna at the point where the line is connected to the antenna. The Antenna Bridge may be used to measure the impedance of the antenna at the point where the transmission line is connected and it may also be used to adjust the matching of the line to the antenna. See section 6 paragraph B for instructions on adjusting the resonant frequency of an antenna, using the Bridge. A balun will be required when the Bridge is used to measure a balanced line.

A transmission line must be terminated in its characteristic impedance at the input as well as its output end. The impedance of the final amplifier in the transmitter will not be equal to the impedance of the transmission line, so an antenna matching device (sometimes erroneously referred to merely as a loading unit) is required to make the necessary impedance transformation. In many cases the transmission line is matched to the antenna only approximately and the antenna matching unit at the transmitter end of the line is adjusted to get the best over all compensation for securing the minimum standing wave ratio. It is absolutely essential that an antenna bridge be used for proper adjustment of the antenna matching network. The antenna matching unit's purpose is to match the over-all impedance of the antenna and transmission line to the transmitter and in some cases to compensate for the reactance left in the transmission line.

3. OPERATING PRECAUTIONS

CAUTION: Reduce the coupling from the grid dip meter before removing the unknown impedance from the bridge, otherwise the very sensitive null indicator will be damaged. Never

use as a power source any pieces of equipment with greater power than a grid dip meter. Never use a transmitter as the power source. See section 5.

4. STANDING WAVE RATIO

Standing waves are caused by energy which is reflected from the terminated end of the transmission line that is not terminated in its characteristic impedance. The reflected energy obviously is not radiated by the transmitting antenna in the case of a transmitter nor is it delivered to the receiver in the case of a receiving antenna. The standing wave ratio is the ratio of the maximum current to the minimum current in a transmission line. When no standing waves are present the maximum and minimum currents are equal and the ratio is one, which means the line is terminated in a pure resistance equal to the characteristic impedance of the line. The standing wave ratio is a measure of the mismatch between the transmission line and its termination.

The power losses in a transmission line are proportional to the square of the current. If the standing wave ratio is too much greater than one the loss increases quite rapidly.

Standing waves on a transmission line to a receiver are caused by reflection at the input terminal of the receiver. The energy is dissipated as described above. In the receiving system it is also necessary to match the re-

ceiving antenna to the transmission line for only then will a maximum signal be delivered at the input of the receiver.

The standing wave ratio is the ratio of the load impedance to the line impedance. To measure antenna resistance, couple the Bridge to the antenna by means of a transmission line which is some multiple of a half wave length long at the desired frequency and resonate the antenna at the desired frequency. The method of accomplishing this is described further in section 6. Make the line a half or 1 wave length long to avoid confusion with multiple nulls.

When a "T" match is used the antenna must be re-resonated with each change of the "T". After a proper null is obtained the transmission line length may be changed from $\frac{1}{8}$ to $\frac{1}{4}$ wave length and the impedance as indicated on the bridge should not change. If the impedance indicated on the bridge is changed when the line length is changed, either the antenna is not resonant at the frequency of measurement or the matching is not complete.

5. RF SOURCE

The RF input for the 90672 Antenna Bridge can be any convenient source of power. The Millen 90651 Grid Dip Meter is the recommended source of power. Since a 50 micro-ampere meter is used as a null indicator on the Bridge, do not use too much RF input. The sensitivity of this bridge is very good, consequently loose coupling to a grid dip meter gives all the sensitivity required until the null is reached. At this point tighter coupling to the grid dip meter may be used but at no time is a power source with more output than the grid dip meter required or permissible.

Three RF pick-up loops are supplied with the Antenna Bridge. The large black coupling coil is resonant in the bridge at approximately 5.2 to 8.8 mc. depending upon the impedance setting. At 500 ohms the large coil is resonant at about 5.2 mc., at 50 ohms it is resonant at about 6.2 mc. and at 5 ohms it is resonant at about 8.8 mc. It should be used for all measurements below 12mc. The large white coupling coil is resonant in the bridge at about 15 mc. at 500 ohms, about 19.1 mc. at 50 ohms,

and about 30.5 mc. at 5 ohms and should be used for all measurements between about 12 and 40 mc. The smallest coupling loop is resonant at about 32 mc. at 500 ohms, about 39 mc. at 50 ohms, and about 84 mc. at 5 ohms and should be used for all measurements above 40 mc. The largest coupling coil and the intermediate coupling coil result in about the same coupling at about 12 mc. When the bridge is set at 50 ohms the intermediate coupling coil and the smallest coil result in about the same coupling at about 40 mc. Since the greatest coupling occurs with the coupling coil at its highest impedance, the coupling coil which is most nearly resonant at the desired frequency is the coil which should be used. It is, of course, possible to make a coupling coil which will be resonant at the particular frequency at which the measurement is desired. However, experience has indicated that the 3 coils supplied with the Antenna Bridge adequately cover the range and that other coils will be required only under certain very special circumstances.

6. DETAILED APPLICATION INSTRUCTIONS

A. GENERAL USE

1. Couple a voltage of the desired frequency to the Bridge. Since a 50 micro-ampere meter is used as a null indicator in the Bridge, the measurement should begin with loose coupling to prevent the possibility of damage to the instrument.

2. Adjust the coupling by moving either the Bridge or the RF source so that the meter indicates on scale somewhere in the vicinity of 40 micro-amperes, off null.

3. Connect the unknown impedance to the antenna jack. Use the proper coupling plug and in no case use lengthy haywire.

4. Adjust dial for minimum meter reading.

5. Read the value of the unknown impedance in ohms directly from the dial scale.

B. RESONANCE

A point which should not be overlooked in measuring antenna impedance is that antenna resonance must be obtained before the minimum standing wave ratio can be achieved. The antenna is resonant at only one frequency and thus at only this frequency is the impedance a pure resistance. Consequently the antenna must be made resonant at the desired frequency before any attempt is made to match the transmission line to the antenna. Any measurement made off resonance will be misleading.

The Antenna Bridge can be used both to determine resonance and to adjust to minimum standing wave ratio. When the antenna is adjusted for minimum meter reading the impedance at which the standing wave ratio is a minimum has been determined. However, if the meter reading is not zero the antenna is not resonant. By a step by step adjustment of the input frequency, one can find the frequency at which the antenna is resonant. If the antenna is not resonant at the desired frequency it will be impossible to obtain a complete null. The Antenna Bridge can be used easily for obtaining both resonance and minimum standing wave ratio. Furthermore, since the resonant frequency is known, the type of adjustments necessary to bring the antenna to resonance at the desired frequency is known; and since the impedance is known, the adjustments required to minimize the standing wave ratio are known. The bridge indicates when the proper adjustment has been made and also indicates which direction to go to obtain the desired result.

C. UNBALANCED LINES

The Antenna Bridge as it stands can be used directly with unbalanced lines. The shielded portion of the line will be grounded directly to the case of the Antenna Bridge and thus hand capacity and stray capacitances will not affect the measurement. Measurement should be made exactly as outlined above in paragraph A.

D. BALANCED LINES

A balanced line may be measured using the Antenna Bridge by the use of a balun coil, a bazooka transformation for transforming 300 ohm balanced twin line to 75 ohm unbalanced line, or in most cases it will be accomplished by the use of the antenna matching network. When either the bazooka transformation or the balun coils are used, the Bridge is operated exactly as if the line were a quarter of its actual impedance. Both the bazooka and the balun result in a 4:1 impedance ratio. Thus a 300 ohms transmission line properly transformed will read 75 ohms on the bridge, or a 600 ohm open line will read 150 ohms on the bridge. Thus the bridge scale of 5 to 500 ohms becomes 20 to 2000 ohms. This coincides with the usual higher impedances of balanced lines. The use of a balun maintains balance during measurement and thus obviates the wild errors usually encountered when one tries to measure any balanced line impedance without first converting it to a single ended load. The balun coils for the amateur bands are available as additional Bridge accessories.

E. ANTENNA MATCHING UNITS

For proper adjustment of an antenna matching unit; the Bridge is substituted for the transmitter. The coaxial cable from the antenna matching unit, which is usually connected to the transmitter, should be connected to the antenna jack on the Bridge. A grid dip meter or other low power source of radio frequency voltage should be coupled to the Bridge coupling coil. **DO NOT UNDER ANY CIRCUMSTANCES LEAVE THE BRIDGE IN THE CIRCUIT WHILE THE TRANSMITTER IS USED.** It is desirable after having adjusted the antenna to resonance at the desired frequency as outlined above, to make a table of the dial readings of the antenna matching network which result in minimum standing wave ratio over the frequency range for which it is intended to use the radiating system. When changing frequency it is necessary only to refer to the table of dial readings on the antenna matching network to assure minimum standing wave ratio.

F. QUARTER WAVE LINES

A quarter wave line left open circuit at the output end appears at the input as a short circuit. Lines odd numbers of quarter waves long which are open at the end also appear shorted at the input. With the Antenna Bridge set at the horizontal line at the 5 ohm end of the scale, find the lowest frequency at which an approximate null occurs. This is the frequency at which the line is a quarter wave length long. At approximately three times this frequency another null will be obtained and this is the frequency at which the line is three-quarter wave length long. The quarter wave frequency in mc. is equal to 246 times the velocity of propagation divided by the length of the line in feet. Thus with the length of line known, the frequency at which the line is a quarter wave length long determined by the means of the Bridge, the velocity of propagation can be determined. A quarter wave line may be used to measure the impedance connected at its end. The impedance measured at the input will be equal to the characteristic impedance of the line squared divided by the load impedance. Thus by measuring the input impedance and the characteristic impedance of the line, it is possible to determine the impedance at the far end of the line. In making any of these impedance measurement using twin lead transmission line be certain that the transmission line is set in the open and kept away from ground, etc.

G. HALF WAVE LINES

A half wave length line short circuited at the output end will appear short circuited at the input end. In other words a half wave line will repeat its termination impedance. Set the Antenna Bridge dial to the horizontal line at the 5 ohm end of the dial scale and find the lowest frequency at which an approximate null is obtained. This is the frequency at which the line is a half wave length long. Any multiple of a half wave length will also produce a null. Half wave lines will repeat at the input end the impedance connected to the output end. Thus a half wave line may be used to determine the impedance in which it is terminated merely by measuring the input impedance.

H. CHARACTERISTIC IMPEDANCE

The characteristic impedance or the surge impedance of a transmission line may be measured by leaving the output end open circuited. Set the Antenna Bridge to the horizontal line at the 5 ohm end of the dial scale, find the lowest frequency at which the transmission line is a quarter wave length long. Now terminate the ends of the transmission line in a resistor. For 50 ohm line use about 30 or 100

ohms. For 100 ohm line use 50 or 200 ohms. For 300 ohm line use about 200 or 600 ohms. Find the new Bridge null, still leaving the rf source frequency at the quarter wave frequency. The characteristic impedance of the line will equal the square root of the Bridge reading, sometimes called the "inverted impedance," times the square root of the load resistance. It may be necessary to measure the load resistance at the frequency in use. It is possible that the "inverted impedance" is not within the 5 to 500 ohm range of the Antenna Bridge. If this should be the case, try a somewhat different terminating resistance until the "inverted impedance" is within the range of the Antenna Bridge.

I. ANTENNA RESONANCE AND RESISTANCE

Since a grid dip meter is generally available as a power source for the Antenna Bridge, antenna resonance is often determined easiest by means of the grid dip meter. However, in many cases where the antenna Q is low, or when the element diameter is large, it is difficult to use the grid dip meter to find antenna resonance and in many cases it is physically impossible to reach the proper point in the antenna without changing the physical position of the antenna. It is often hard to couple to a long wire at low frequencies, thus in many cases it is convenient to determine the antenna resonant frequency by means of the Antenna Bridge. Paragraphs J through O discuss measurements on particular types of antennas.

J. HALF WAVE DIPOLES

The easiest way of determining the resonance of a dipole antenna is to use a half wave transmission line between the antenna and the Antenna Bridge. The transmission line should be a half wave length long at the resonant frequency of the antenna. This is not as ambiguous as it sounds on the surface, because the frequency of the antenna is known approximately because the physical length in the standard formula will give the approximate frequency. The transmission line should be cut to a half wave at this calculated frequency. Cut the line slightly long so that successive approximations may be made so that a precise measurement may be made.

It is often desirable to cut an antenna to a particular resonant frequency rather than to measure the resonant frequency of an existing antenna. In this case, the transmission line should be made a half wave length long at the desired frequency and the antenna pruned to resonance. One precaution should be observed: The half wave length line **must** be at right angles to the antenna for at least a quar-

ter wave length in order to eliminate any coupling between the antenna and the transmission line. Failure to observe this precaution will result in erroneous answers. At high frequencies, it may be desirable to use a transmission line which is some multiple of a half wave length long. The impedance of the transmission line is not important, since it is being used only as an impedance "repeater" rather than to match the antenna.

If a balun is available, and if the frequency of measurement is lower than about 50 mc., the bridge may be used directly at the center of the antenna. Since the center impedance of a dipole is about 72 ohms, set at the Bridge dial to about $72/4$ equals 18 ohms and adjust the source frequency and Bridge dial for null. Here again, do not be too alarmed if the measurement does not coincide with previous impressions. The impedance should be dependent on the height of the antenna above ground. It can be determined whether the positions of the Antenna Bridge and the operator near the center of the antenna result in erroneous readings, by noticing whether or not the meter null changes when the operator moves away from the antenna. If position errors exist it will be necessary to resort to a half wave transmission line to measure as outlined in paragraph J above. At frequencies above 50 mc., the presence of the bridge and the operator at the center of the antenna will probably result in errors which will not occur when the bridge and the operator are removed from the center of the antenna. If a balanced transmission line, such as open line or twin line is used between the antenna and the Bridge, line unbalance to ground may be reduced by twisting the line every couple of feet or so. If a different reading is obtained when the line connection to the balun is reversed, unbalanced line to the ground capacity is indicated and should be corrected by twisting the transmission line.

K. FOLDED DIPOLES

The Bridge balun or the half wave line should be connected to the center of one side of the folded dipole (the point at which the transmission line is usually connected). The radiation resistance of the folded dipole is usually between 150 and 300 ohms or so. If the folded dipole is made of twin line it has a velocity of propagation such that the quarter period of the quarter wave length line is about 86% of the over all natural quarter period. Two impedances will be indicated on the Bridge. The correct indication is the one between 150 and 300 ohms, and the incorrect indication will be around 500 ohms. Consequently, the correct Bridge reading is the one that occurs at the highest frequency. This type of antenna results in narrow band pass. It is possible to

use the Antenna Bridge to compensate for the velocity of propagation and thus broaden the frequency response of a twin lead dipole to equal the band pass of an open wire dipole. One method of compensation is to place in series with the shorted ends a capacity of about 7 mmf per meter of wave length and tune each quarter wave section to the over all natural frequency. Another is to place short circuits at 86% of the normal distance from the center to each end. Another method is to cut the line of the folded dipole so that it is 492 times the velocity of propagation divided by the frequency in mc. feet long. A transmission line of twin lead should be cut to a half wave length at the desired frequency as outlined above in paragraph G. Short circuits should be placed at ends of the antenna. Open one side of the antenna and connect the Bridge balun or the half wave transmission line "repeater". Add a wire to each end of the folded dipole. Clip the wires back until antenna resonance is indicated at the desired frequency. The frequency response of an antenna made in this manner will approximate that of an open wire folded dipole.

L. HARMONIC ANTENNAS

To measure antennas any multiple of a half wave length long, connect the balun or the half wave transmission line "repeater" at any high current point.

M. QUARTER WAVE VERTICAL AND GROUND PLANE ANTENNAS

The impedance measured at the bottom of a quarter wave antenna is of the order of 35 ohms. The Bridge should be connected between the bottom of the antenna and the ground plane. If the transmission line impedance is higher than the end impedance of the vertical antenna, which is the usual case, the feed point impedance may be increased by increasing the angle between the radiator and the ground plane radials. Use the Antenna Bridge to determine the proper angle of the ground plane radials. The limit that can be achieved is about 70 ohms at which point the angle between the antenna and the ground plane radials is 180° and the antenna is a coaxial antenna.

N. MOBILE ANTENNAS

The bottom impedance of a quarter wave radiator placed on a car will be about 45 ohms. This impedance can be measured exactly as described in paragraph M above. For base loaded or center loaded antennas, the impedance will be 20 to 35 ohms. In order to measure, the base loading should be connected between the base of the antenna and the Antenna Bridge,

and the Antenna Bridge should be connected between the base loading and the ground plane of the car. Use the Antenna Bridge to determine what L and C are required for base loading, in order to match the antenna to 50 to 70 ohm transmission line.

O. PARASITIC BEAMS

The bridge should be connected by means of a balun or a half wave transmission line "repeater" to the center of the driven element. The impedance at this point will probably lie between 5 and 100 ohms. More than one null will be obtained due to the reflections from other elements, however, a properly tuned beam will have only one **complete** null at the true resonant frequency. Adjust the length of the driven element to resonance as described in paragraph I. The reflectors should then be cut to 5% longer than the driven element and directors should be cut about 5% shorter than the driven element. It is, of course, possible to tune the reflectors and directors but the improvement in the performance is seldom worth the additional effort.

P. ADJUSTING Q BARS

Q bars are used as a quarter wave trans-

former to match the antenna resistance to the line characteristic impedance. Connect the end of the bars to the Bridge balun or half wave transmission line "repeater" and the other end to the antenna. Adjust the spacing for the desired impedance. However, before the Q bars can be adjusted, the antenna must be resonant as determined in paragraph I and the Q bars must be a quarter wave length long.

Q. RECEIVER INPUT IMPEDANCE

If the receiver input is unbalanced, connect the bridge directly to the receiver input. If the receiver input is balanced, connect the receiver input to the Bridge balun. The input circuit of the receiver must be resonant in order to measure the input resistance. Over coupling between the antenna coupling coil and the first tuned circuit is a common condition and will be indicated by two bridge measurements, one of which will be in the vicinity of 5 to 20 ohms and the other 50 to 1500 ohms. Too loose coupling between the antenna coupling coil and the first tuned circuit is indicated by an incomplete null which results because the input is reactive.

The receiver input impedance may be matched by a network such as the Millen No. 92101 Antenna Matching Preamplifier.

7. TECHNICAL SUMMARY

POWER INPUT

No D.C. or 60 cycle power required.

A small fraction of a watt of rf power is required. It is suggested that a Millen 90651 Grid Dip Meter be used to supply this power.

IMPEDANCE RANGE

Unbalanced—5 ohms to 500 ohms

Balanced—20 ohms to 2000 ohms using balun not supplied with Bridge.

ACCESSORIES (Not included)

Millen 90651 Grid Dip Meter.

Baluns for the amateur bands.

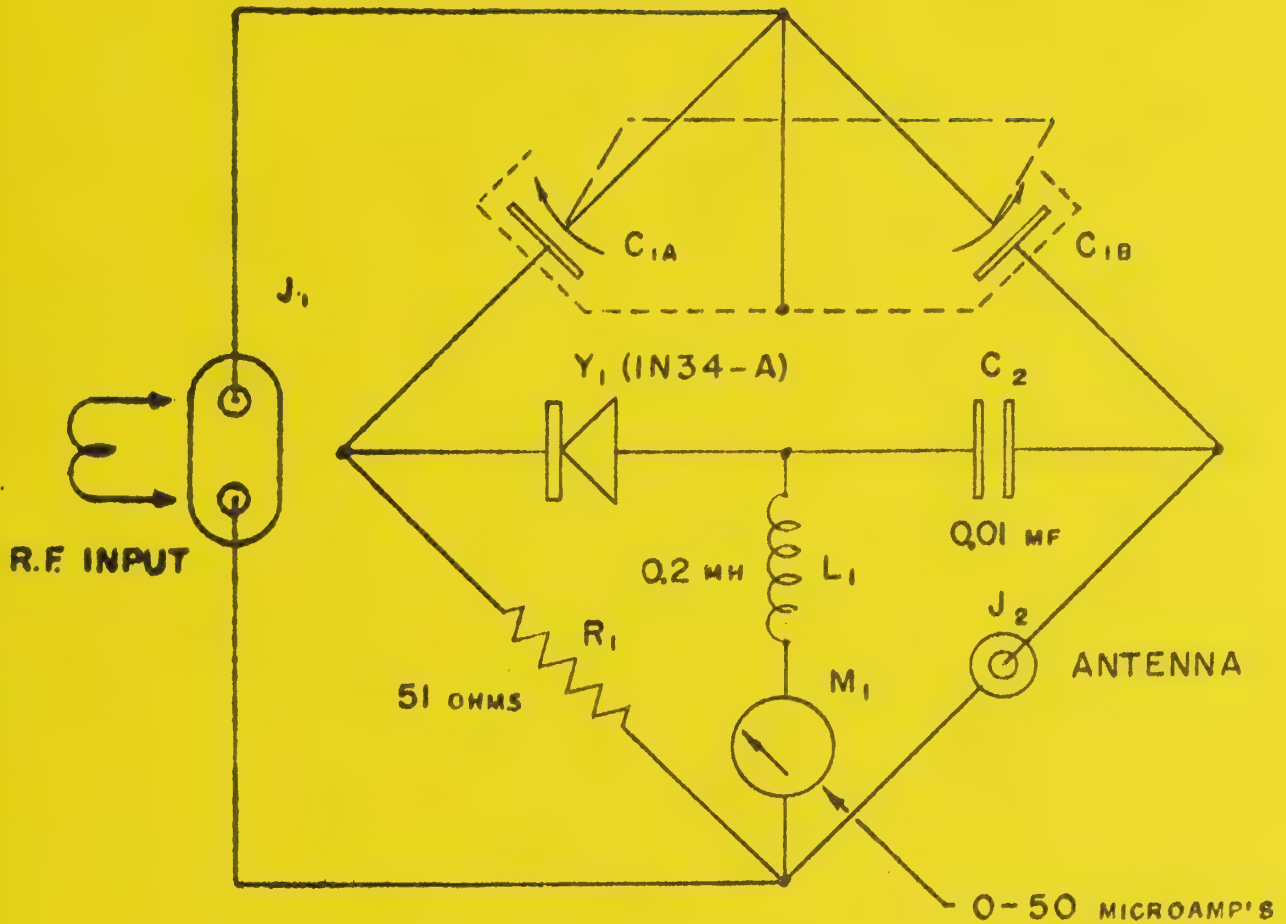
PHYSICAL DIMENSIONS

Length— $5\frac{5}{8}$ inches.

Width— $3\frac{1}{8}$ inches, plus rf connector.

Height— $3\frac{7}{8}$ inches, including knob.

Weight— $1\frac{5}{8}$ pounds.



ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

ANTENNA BRIDGE

FIRST MADE FOR

DESIGNED BY R.W.C.
DRAWN BY R.KAROSAS

CHECKED BY R.W.C.
APPROVED _____

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K 90672

DATE
8-23-55

2

2000

1500

CALIBRATION OF LOW FREQUENCY INDUCTORS

FOR JAMES MILLEN *90651 OR *90661

GRID DIP METER

FREQUENCY IN KILOCYCLES

1000

900

800

700

600

500

400

300

200

NO. 46702 925 TO 2000 KC.

NO. 46703 500 TO 1050 KC.

NO. 46704 325 TO 600 KC.

NO. 46705 220 TO 350 KC.

DIAL

JAMES MILLEN MFG. CO., INC.

1-31-50

2



JAMES MILLEN

MANUFACTURING COMPANY, INC.



"Designed for Performance"®

NO. 90651 GRID DIP METER

The Millen No. 90651 Grid Dip Meter is now available in a convenient polypropylene carrying case which keeps the coil/probes with the Grid Dip Meter and protects both.

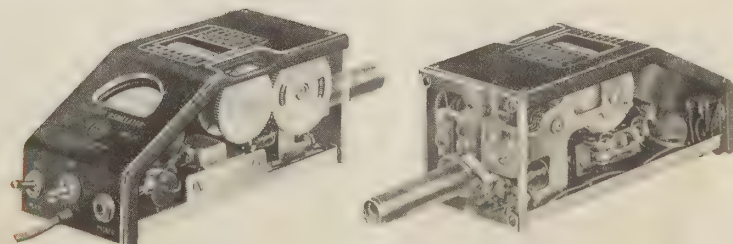
Frequency coverage is 1.7 to 300 mc. with the seven coil/probes furnished. Additional coils for extending the calibration to 225 KC. are available.

The Millen Grid Dip Meter is a calibrated stable RF oscillator unit with a meter to read grid current. The frequency determining coil is plugged into the unit so that it may be used as a probe.

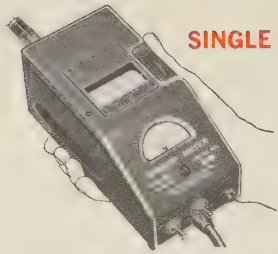
This instrument is complete with a built-in transformer type A.C. power supply and internal terminal board to provide connections for battery operation where it is desirable to use the unit on antenna measurements and other uses where A.C. power is not available. Compactness has been achieved without loss of performance, convenience of use, or ease of reading the dial accurately. The incorporation of the power supply, oscillator, probe, and easily read dial into a single hand-held unit provides a convenient device for checking all types of circuits. The indicating instrument is a rugged 2 inch meter with easy-to-read scale. The calibrated dial is a large 205° drum dial which provides seven direct reading scales, plus an additional universal scale, all with the same length and readability. Each frequency range has its individual plug-in coil/probe completely enclosed in a molded contour fitting polystyrene case for assurance of permanence of calibration as well as to prevent any possibility of mechanical damage or of unintentional contact with the components of the circuit being tested. The coils and dial scales are color coded.

JAMES MILLEN

MANUFACTURING COMPANY, INC.



FEATURES OF 90651 GRID-DIP METER



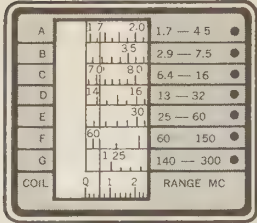
SINGLE HAND-HELD GRID DIP METER

CONVENIENT, one-hand operation permits thumb-setting on any segment of its frequency range; frees second hand.



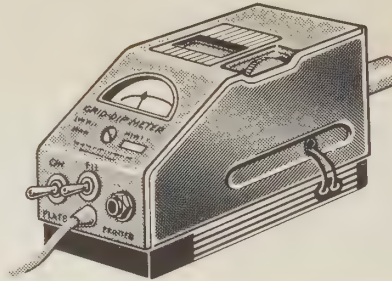
EASY-TO-READ METER

RUGGED METER is placed on the distinctive sloping panel for maximum reading accuracy from the large easy-to-read scale.



EASY-TO-READ DIAL

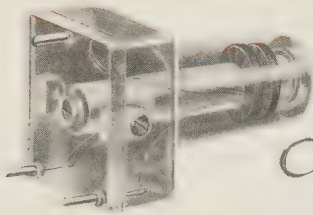
THE CALIBRATED dial is a large 205° drum dial which provides seven direct reading scales plus an additional universal scale.



DESIGNED FOR BATTERY USE

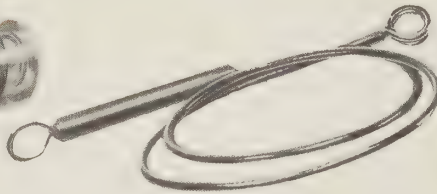
CONNECTIONS are available for battery operation when used away from A.C. power lines; i.e. antenna installations and measurements.

ACCESSORIES FOR USE WITH 90651 GRID-DIP METER



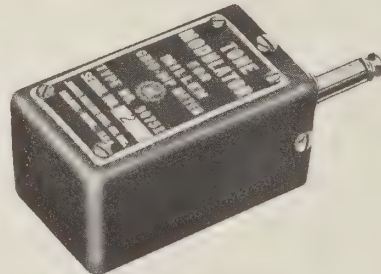
LOW FREQUENCY COIL/PROBES

No. 46702 — 925 to 2000 KC.
No. 46703 — 500 to 1050 KC.
No. 46704 — 325 to 600 KC.
No. 46705 — 220 to 350 KC.



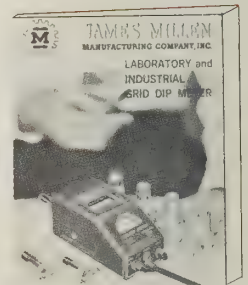
No. 46721 PROBE

The No. 46721 Probe is used under many conditions where it is difficult to couple directly to the unknown circuit.

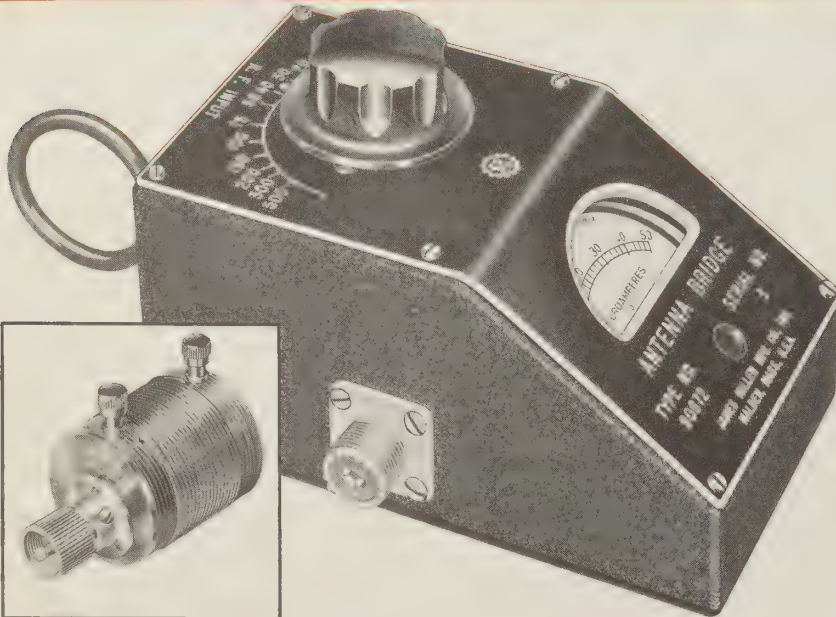


TONE MODULATOR

The No. 90751 Tone Modulator plugs into the 'phone jack of a Grid Dip Meter to provide 800 cycle modulation.



Also available are Industrial models of the Grid Dip Meter, Nos. 90662-A and 90661. Send for Industrial Grid Dip Bulletin.



NO. 90672 ANTENNA BRIDGE

The No. 90672 Antenna Bridge is an accurate and sensitive bridge for measuring impedance in the range of 5 to 500 ohms for unbalanced impedance and 20 to 2000 ohms for balanced impedance (using the 4:1 balun illustrated) at radio frequencies up to 140 mc. The variable element in this bridge is an especially designed differential capacitor of high accuracy and permanence of calibration over a wide range of frequencies. This bridge is entirely unique in design as compared to others designed for the same type of service, because it employs no variable resistors. The No. 90672 was designed to use a Grid Dip Meter, such as the Millen No. 90651, as a source of RF signal.

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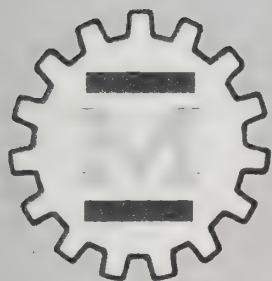
MAIN OFFICE



MFG. CO., INC.

AND FACTORY

150 EXCHANGE ST., MALDEN, MASSACHUSETTS, U. S. A.



JAMES MILLEN

MANUFACTURING COMPANY, INC.



NO. 90651

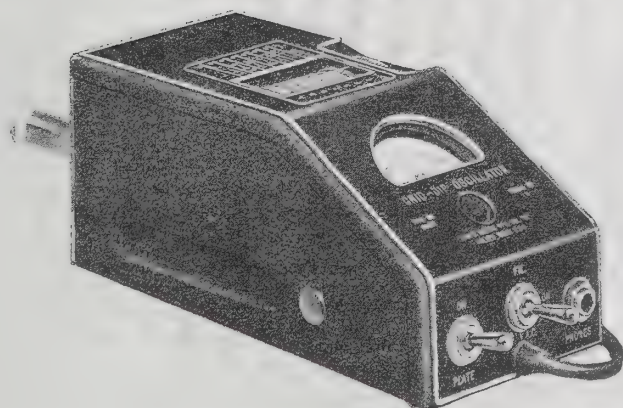
GRID DIP METER

The Millen No. 90651 Grid Dip Meter is now available in a convenient polypropylene carrying case which keeps the coil/probes with the Grid Dip Meter and protects both.

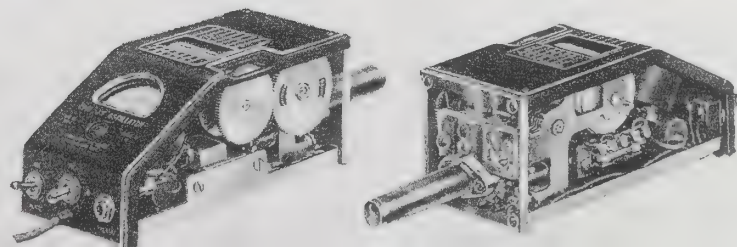
Frequency coverage is 1.7 to 300 mc. with the seven coil/probes furnished. Additional coils for extending the calibration to 225 KC. are available.

The Millen Grid Dip Meter is a calibrated stable RF oscillator unit with a meter to read grid current. The frequency determining coil is plugged into the unit so that it may be used as a probe.

This instrument is complete with a built-in transformer type A.C. power supply and internal terminal board to provide connections for battery operation where it is desirable to use the unit on antenna measurements and other uses where A.C. power is not available. Compactness has been achieved without loss of performance, convenience of use, or ease of reading the dial accurately. The incorporation of the power supply, oscillator, probe, and easily read dial into a single hand-held unit provides a convenient device for checking all types of circuits. The indicating instrument is a rugged 2 inch meter with easy-to-read scale. The calibrated dial is a large 205° drum dial which provides seven direct reading scales, plus an additional universal scale, all with the same length and readability. Each frequency range has its individual plug-in coil/probe completely enclosed in a molded contour fitting polystyrene case for assurance of permanence of calibration as well as to prevent any possibility of mechanical damage or of unintentional contact with the components of the circuit being tested. The coils and dial scales are color coded.



JAMES MILLEN
MANUFACTURING COMPANY, INC.

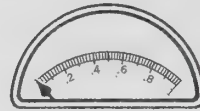


FEATURES OF 90651 GRID-DIP METER



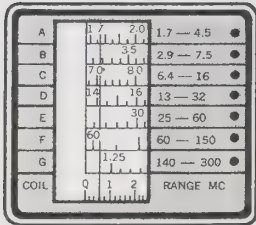
SINGLE HAND-HELD GRID-DIP METER

CONVENIENT, one-hand operation permits thumb-setting on any segment of its frequency range; frees second hand.



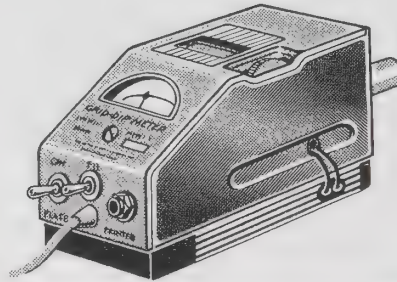
EASY-TO-READ METER

RUGGED METER is placed on the distinctive sloping panel for maximum reading accuracy from the large easy-to-read scale.



EASY-TO-READ DIAL

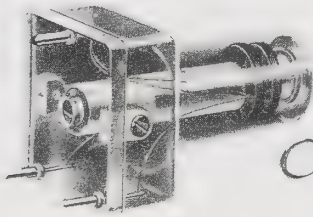
THE CALIBRATED dial is a large 205° drum dial which provides seven direct reading scales plus an additional universal scale.



DESIGNED FOR BATTERY USE

CONNECTIONS are available for battery operation when used away from A.C. power lines; i.e. antenna installations and measurements.

ACCESSORIES FOR USE WITH 90651 GRID-DIP METER



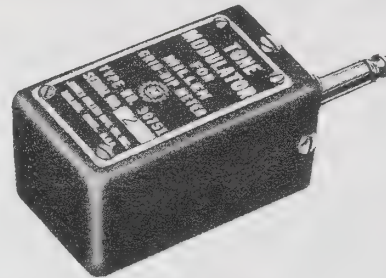
LOW FREQUENCY COIL/PROBES

No. 46702 — 925 to 2000 KC.
No. 46703 — 500 to 1050 KC.
No. 46704 — 325 to 600 KC.
No. 46705 — 220 to 350 KC.



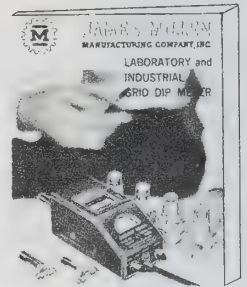
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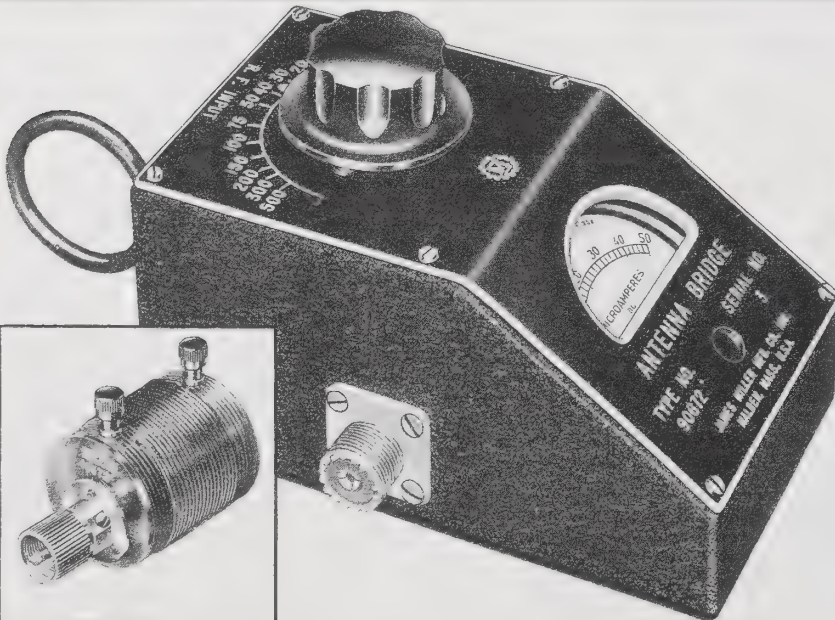


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MFG. CO., INC.

MAIN OFFICE

AND FACTORY

150 EXCHANGE ST. MALDEN, MASSACHUSETTS, U. S. A.

No. 90651 GRID-DIP METER

I. GENERAL

The Millen 90651 Grid-Dip Meter may be used in any of the following manners:

1. **Grid-dip oscillator** for use as an oscillating frequency meter to determine the resonant frequency of de-energized r. f. circuits.

Plate potential is applied to the Grid-Dip Meter and it becomes an r. f. oscillator. A d.c. meter in the grid return indicates relative power. When a circuit, resonant at the oscillator frequency, is coupled to the "probe" inductance, power is absorbed from the oscillator by the resonant circuit and is so indicated by a dip (decrease) in the grid meter reading. The "Grid Dipper", employed in this manner, may then be used to check the resonant frequency of a circuit without the application of power to the circuit in question. This results in a considerable saving of time, and a definite assurance of correct frequency adjustment of a circuit is obtained. Circuits may be checked or pretuned before completion of the unit in which they are to be used. Only minor trimming is generally required under actual operation. Guesswork or "cut and try" methods are eliminated. Possible damage to components during initial tune up and adjustment is eliminated.

2. **Oscillating detector** for determining the fundamental or harmonic frequencies of energized r.f. circuits.

Plate potential is applied and the instrument is used as an r.f. oscillator. Instead of observing the grid-meter reading, a pair of phones is inserted in the phone jack and an audible beat may be heard when the instrument is tuned to the fundamental or harmonic frequency of a source of r.f. The frequency may be read directly from the calibrated dial.

3. **Signal generator.** The instrument may be employed for this purpose generally in place of a standard signal generator, except where special shielding or a known r.f. output voltage is required.

4. **Tuned r.f. diode or non-oscillating detector** for use as an absorption-type frequency meter. No plate potential is applied and the internal tube is used as a diode. The grid meter is then in the diode load circuit and will read up-scale (current increase) when the instrument is tuned and closely coupled to a source of r.f. energy.

II. METHODS OF COUPLING

Correct methods of coupling the grid-dip meter to circuits under tests are shown in Fig. 1. When used as a grid-dip oscillator harmonics of lumped-constant resonant circuits will not be indicated; however, other resonant frequencies are sometimes indicated. These will be due to other resonant circuits formed by circuit wiring, stray capacitances, etc. In most cases these will occur at a higher frequency. On the other hand, harmonics of antennas, transmission lines, etc. will be indicated as will be explained later in the text under the heading "antennas."

When looking for the grid dip, it will be noted that the grid current reading slowly varies as the dial is rotated; however, correct resonance is indicated when the meter takes a sharp or pronounced dip.

It is suggested that the user of the "Grid Dipper" at first set up test L/C combinations, short test antennas, etc., and check them with the instrument in order to become familiar with the coupling methods and with the general behavior and operation of the unit.

Coupling too tightly will cause a deep sharp dip and a sudden rise. This tight coupling pulls the oscillator frequency somewhat, and makes it difficult to determine the resonant frequency. Over-coupling will cause inaccuracy in determining the resonant frequency. The solution is to back the Grid Dip Meter away from the test coil until the dip is barely perceptible. With this coupling there is no difficulty in determining the resonant frequency and the measurement will be accurate.

III. APPLICATIONS

Receiver tuned circuits. Use the instrument as a grid-dip oscillator. Remove power from the receiver and resonate each tuned circuit to the desired frequency as indicated by the meter dip. Gang tuned circuits should

be aligned for tracking by checking at each end of the ganged range. A check at one or two points in between will also be helpful. Methods of electrically obtaining the desired bandsread or tracking will not be explained

here. Reference may be made to any good radio text book.

Following the above procedure, power may be applied to the receiver and the grid-dip meter employed as a signal generator for checking final alignment. A very short antenna should be connected to the receiver input terminals and the "Grid Dipper" should be placed on the bench removed from nearby conductors, and where body movements are least apt to affect the r.f. signal from the instrument. Some sort of indicating device such as an "S" meter or v.t.v.m. at the receiver detector must be used. If the r.f. signal is too strong, the receiver antenna may be shortened, or the instrument may be removed to a more remote or partially shielded location.

Where a superheterodyne type of receiver is involved and, if the receiver fails to function, it is quite possible that the receiver local oscillator is not working. This may be checked by employing the "Grid Dipper" as an r.f. diode detector or absorption type wave meter. Couple it to the oscillator coil and, if the meter does not go up-scale when the instrument is tuned to the resonant frequency of the oscillator tank, the oscillator is not functioning. An alternative method having greater sensitivity and capable of more accurate frequency measurement is to use the instrument as an oscillating detector and listen for the local oscillator beat in the headphones.

Transmitter tuned circuits. Use the instrument as a grid-dip oscillator with plate power removed from transmitter and proceed to adjust tanks to desired frequency as with receiver circuits. Tubes should be in place, and where capacitive coupling is used between stages, the grid circuit associated with following tube should be completed.

After the above procedure, plate power may be applied and final alignment made according to grid and plate meter indications. R.f. power at correct frequency in each tank may be checked by employing the "Grid Dipper" as a diode absorption frequency meter or it may be utilized as an oscillating detector. Due to its greater sensitivity in the latter state, care must be taken not to mistake audible beats from some other energized r.f. circuit. This may be checked by moving the instrument closer to the circuit under test and noting whether or not the beat increases in volume. If it does, the beat heard is from the desired circuit. Harmonics also may be heard, so it is wise to check for the beat heard at the lowest frequency.

Neutralization. Employ the instrument as a grid-dip oscillator. Remove all plate power from the transmitter. Couple the "Grid Dipper" to grid tank of stage to be neutralized, or in the case of capacitive coupling to the preceding plate tank (it is assumed that the tank has already been tuned to correct frequency). Couple fairly close and leave instrument set in position with its meter deflected at bottom of the resonant dip. Neutralization is then indicated when rotation of amplifier plate tank capacitor has no reaction on the deflected meter reading. Another method is to use the instrument as a diode absorption-type meter and proceed to neutralize in the manner normally employed when using absorption-type wavemeter, or as with similar indicating device, i.e.:

Remove plate power from amplifier stage to be neutralized, and apply power to stage driving the grid. Couple the "Grid Dipper" to the amplifier tank, tune the instrument to the driving frequency and check for the presence of r.f. in the tank as indicated by a rise in the "Grid Dipper" meter current. Adjust neutralizing capacitor until no reading is seen on the meter.

Parasitic oscillations. Apply power to transmitter and use instrument as an oscillating detector while listening on headphones for beat of parasitic oscillation. As an alternative, the parasitic frequency may be determined by using the instrument as a tuned r.f. diode or absorption type frequency meter. When parasitic frequency has thus been determined, as read from the "Grid Dipper" scale, remove power from transmitter and use instrument as a grid-dip oscillator to locate circuits or components, such as r.f. chokes, circuit wiring, etc., resonant at parasitic frequency.

Parallel resonant traps. Use as a grid-dip oscillator. Trap may be tuned or checked either before or after connecting it in desired circuit. If tuned before installation, adjustment will remain correct upon installation if its inductance is physically removed from other conductive components which may alter the inductance value. This is not usually the case, so further minor adjustment will probably be required after installation. When in the circuit, it is possible that its resonant frequency may be quite a bit off as indicated by the "Grid Dipper". Actually the trap itself will still be tuned to approximately correct frequency but the grid-dip oscillator reading may be found at some other frequency (usually lower) due to circuit "strays" across the trap.

Final precise adjustment may be made by applying power to circuit and by tuning trap under actual operation for desired effect. In many cases this will not be necessary as pre-tuning is quite accurate.

Series resonant traps. Follow same general procedure as with parallel resonant trap. To check or tune prior to installation, trap may be first connected as a parallel trap. At high frequencies or where the trap inductance is low, the lead completing the parallel circuit should be of large wire or wide copper ribbon to keep its inductance low, and care should be taken not to permit this lead to be positioned so as to add stray capacitance. Leads to be used upon final installation must also be included when external measurements are being made.

R. F. chokes. To determine self resonance of r.f. chokes, use "Grid Dipper" as a grid dip oscillator.

Measure circuit Q. Use the "Grid Dipper" as signal generator. Connect a v.t.v.m. across the circuit to be measured. Couple instrument to circuit (Fig. 1A) and resonate for maximum, or peak reading, on v.t.v.m. Note frequency at which this occurs. Then shift the instrument each side of resonance to the frequency where the voltmeter reading drops to approximately 70.7% of that at resonance. Note the frequency of these two points and calculate the circuit Q from equation "A", Appendix 1, where f_r is the resonant frequency and Δf is the difference between the "off resonance" frequencies just found. The original coupling should be adjusted for a convenient maximum reading of the v.t.v.m. and then should be left fixed at this position for the remainder of the procedure.

When the circuit Q is quite high, it may be necessary to check the frequencies with a calibrated receiver, because the "off resonance" points will occur too closely together for accurate reading on the instrument scale.

Relative circuit Q at a given frequency. Use as a grid-dip oscillator and observe character of the dip whether broad or sharp. The sharper the dip, the higher the Q.

Measurement of capacitance. Several methods may be employed. All involve the use of the "Grid Dipper" as an oscillator.

A small jig (Fig. 2) must be made, into which may be plugged any one of the "Grid Dipper" coils.

To check an unknown capacitor, it is then only necessary to clip the jig, with a coil inserted, across the unknown capacitance. Find the resonant frequency and refer to the calibration chart for value of capacitor with the coil employed. For over-all accuracy, it is best to employ one of the coils from the medium frequency range.

Due to the distributed capacitance of the coils, a slight error will be encountered at very low capacitance measurements. Likewise, due to self inductance of large capacitors, a small error will be found when measuring these. Errors will be negligible for most practical purposes.

Measurements below 50 mmf are generally not obtainable because resonance at these values usually falls out of range of the coils left available for frequency checking. For measurements below 50 mmf an additional calibrated coil is required.

For these measurements, in a great number of cases, the capacitor need not be removed from the circuit in which it is wired unless the capacitor is heavily loaded.

Another method, similar to that above, is to employ a known inductance and find the resonant frequency with the unknown connected across it. See equation "B" Appendix 1 where f is the resonant frequency in cycles and L is the inductance in henries. C_x will be in farads.

A third method, for capacitors up to about 1000 mmf, requires an inductance which is shunted by a calibrated variable capacitor. The capacitor is set at maximum and the resonant frequency of the circuit is found. The unknown capacitor is then connected across the variable and the capacitance of the latter decreased to a point where the circuit resonates at the original frequency. The difference between the first and last settings of the calibrated variable capacitor is the value of the unknown.

Measurement of inductance of r.f. coils. Connect a capacitor of known value across the coil and use the "Grid Dipper" as a grid-dip oscillator to find the resonant frequency of the resulting L/C combination. The inductance of the coil may be calculated from equation "C" Appendix 1 where L_x is in henries, C is known capacitor in farads; or reference may be made to an L/C -resonance chart.

In measuring small values of inductance, be sure to employ a low inductance standard condenser, connected to the unknown coil by

wide ribbon, in order to obtain most accurate results. Due to the distributed capacitance, especially in large coils, some slight error will result; however, if the value of the low inductance known capacitor is fairly high, the error will be negligible.

Relative Q of capacitors or inductances at a given frequency may be noted by observing the character of the dip, as previously described.

Antennas. Use instrument as grid-dip oscillator. Coupling should be made at a low impedance or high current point as shown in Fig. 1E. This point, for a half wave antenna, is at the center, and for longer wires is at points odd quarter wavelengths measured from either end. It will be observed that a full-wave antenna will not be a half-wave at exactly half its resonant frequency. This is because the end effects are found only at the antenna ends and will be absent at other points when the antenna is a full wave or more long. It is therefore always necessary to measure an antenna under the conditions desired (relating to physical and electrical length). Measurement should be made with the antenna placed as near as possible to its ultimate operating position. Checks on a given antenna at different heights or positions will show an amazing difference in antenna resonance.

If it is physically impossible to reach a low impedance point, a check may be made at a high-impedance or high-voltage point. Capacitive coupling should be used as shown at Fig. 1F. If the high impedance point involved is one of the ends, the end effect will be altered due to the presence of the instrument and the resonant frequency of the antenna will slightly decrease. This must be taken into consideration when making measurement, i.e., the reading indicated will be slightly lower than true antenna resonance (with "Grid Dipper" away from end). This difference will be about 1 to 3% and will be encountered only when checking at the ends.

In all cases it is helpful to keep in mind the physical length in feet vs. electrical length (half-wave, full-wave, etc.) as calculated approximately by formula. Unlike lumped resonant circuits, antenna harmonics are detected when using the "Grid Dipper." As previously mentioned, these harmonics will not occur at exact multiples of a half-wave.

When measurement is made, the feeders should be disconnected from the antennas. Unless the feeders happen to be perfectly

matched or terminated, true antenna resonance will not be indicated because unmatched feeders or incorrectly terminated feeders will present either a positive or negative reactance and will, therefore, alter the electrical length of the antenna.

When the antenna element is of very large diameter, such as is often found in rotating beams, sufficient coupling to the "Grid Dipper" may not be obtained and some difficulty will be encountered in finding a reading. This condition may sometimes be relieved by jumping a foot or so of the antenna at the center with a small diameter wire and coupling to this wire.

If the antenna is to be normally used with its center open, close it with the shortest possible wire during measurement. This must be done also with the folded dipole. The short may later be removed, if required, when feeders are connected.

Tuned or resonant feeders, such as used in the Zepp antenna. Use instrument as grid-dip oscillator and check for desired resonance at the series or parallel tuned circuit on the transmitter end of the feeder. If resonance at the desired frequency is not obtainable, alterations may be made in the tuned circuit or the feeder length according to the actual resonant frequency found. Care must be exercised not to become confused by other resonance indications. It must be remembered that a Zepp is actually a long wire antenna partially doubled back on itself and resonance can therefore be noted at frequencies both higher and lower than the desired one.

Untuned or non-resonant feeders. After the antenna has been adjusted to the correct length, an untuned feed line may be connected employing some system of matching. Correct match may be obtained by making adjustment while employing a transmission impedance bridge or a standing-wave-ratio meter and using the "Grid Dipper" (set at antenna resonant frequency) as the signal generator.

The transmission bridge or the s-w-r meter should employ a meter of full scale sensitivity of 200 μ a or less, for most accurate readings. Coupling to the "Grid Dipper" should be as loose as possible consistent with obtaining sufficient reading. If the coupling is too tight, the instrument frequency calibration may be slightly shifted.

The matching device should then be adjusted for as near unity standing-wave-ratio as

possible. If a satisfactorily low standing-wave-ratio is unobtainable, it is due to either a fault in the matching system or due to a shift in antenna resonance. The latter may be checked by slightly varying the "Grid Dipper" frequency until a lower s.w.r. is found or until a better s.w.r. meter null is indicated. The frequency at this point will be that of antenna resonance. If necessary, the antenna length may then be changed until the correct standing-wave-ratio is realized at the desired frequency. It may also be necessary to trim up the adjustment of the matching system.

Tuning the parasitic beam. Use the instrument as grid-dip oscillator and adjust driven element for resonance. The feeder should be disconnected and the parasitic elements should be set at their calculated correct length. If the driven element is open at the center, close it. After this element has been properly set, connect and match feeder as described in the foregoing paragraph (open antenna center if matching system so requires). The parasitic elements may then be adjusted using the "Grid Dipper" as the signal generator coupled to the feed line and by observing readings on a receiver (with an "S" meter) connected to a short antenna some distance away. Relative field readings in actual "S" units then may be obtained after each adjustment. As when matching feeder, coupling to the "Grid Dipper" should be as loose as possible. It is a good idea to occasionally check the actual frequency of the instrument on the receiver.

Following the tuning of the parasitic elements, the standing-wave-ratio should again be checked. It will, undoubtedly, increase, because tuning of the other elements will cause a change in antenna resonance. This will have to be altered accordingly, as described under "matching of non-resonant lines." Repetition of the preceding steps is advisable for putting on the finishing touches.

If the beam is located so that surrounding objects are likely to cause detuning as the beam is rotated (this may be checked during antenna and parasitic element tuning), it may be advisable to do the final retuning with the beam positioned either towards the direction in which it will be mostly used, or where the greatest degree of rotation has the least effect.

Needless to say, the transmitter may be used as the signal generator in place of the "Grid Dipper" during the above adjustments; however, the employment of the "Grid Dipper" for this purpose is more convenient, because the entire operation may be handled right on

the roof by one person, or wherever the beam is located. The use of the instrument also keeps the channel free from unnecessary QRM.

Quarter-wave shorted lines. Use as a grid-dip oscillator and couple for open wire lines as at Fig. 1G, and for coaxial lines as at Fig. 1H. When trimming lines for correct length, fittings to be used eventually for connections should be installed on the end of the line. The approximate frequency of the line may be determined by rough calculation. Other resonant points can be found, however. These will be at three times the fundamental quarter-wave, where the line is then three-quarter waves long, or five times the fundamental quarter-wave, etc.

Quarter-wave open lines. For open-wire lines, connect a short at one end and measure as for quarter-wave shorted line. Due to the length of the short, the actual electrical length of the line (used as an open line) will be slightly in error depending on the line spacing. The closer the spacing, the smaller the error.

For coax lines, place short on line and measure as quarter-wave shorted line. The short should be as direct and short as possible from inner conductor to shield in order to avoid errors. Fittings should also be included. Remove the short after measurements are completed.

Half-wave shorted lines. For open-wire lines, couple at center as shown at Fig. 1I. For coax line, measure for quarter-wave shorted line at half the calculated or desired frequency. Resonant frequency thus found must be then multiplied by 2 for a resulting half-wave shorted line.

Half-wave open lines. For open-wire lines, couple at center as shown at Fig. 1I. For coax line, short one end and measure for quarter-wave shorted line at half the calculated frequency. Resonant frequency thus found must be multiplied by 2 for the correct length of the line after short is removed; provided the short is made direct as mentioned above.

Check standing waves. Aside from employing the "Grid Dipper" as the signal generator in conjunction with a standing wave ratio meter, open-wire feed lines may be checked for the existence of standing waves by using the instrument as a diode detector. A flat line is indicated when the meter reading remains constant as the "probe" coil is moved along the line. Care must be used to maintain uniform

distance or coupling between coil and line. Since the "Grid Dipper" coil is protected by an insulated sleeve, the coil form may be held against the line for maintaining uniform coupling.

This method is the same as that using a neon bulb, crystal detector or other similar device.

Relative field-strength meter. Use the "Grid Dipper" as diode detector. Connect a short antenna to one of the coil posts through a 5-30 mmf capacitor. The instrument's frequency calibration will shift some, so the dial

will have to be rotated for maximum reading of the received signal. Actual frequency calibration is unimportant for this purpose. Sensitivity of the "Grid Dipper" as a field meter is not as great as that of some other devices, but it will, nevertheless, be helpful in many cases.

The "Grid Dipper" may be employed for a number of other measurements, principally when utilized as a signal generator. Its use as a grid-dip oscillator will be quite obvious and self suggestive for measurement of many other types of equipment and circuits. The applications herein described are those which will be generally most useful.

IV. POWER SUPPLY

The 90661-90651 is supplied complete with its own internal power supply. The unit will operate on 105 to 125 volts at 50 to 60 cycles per second. If it should become necessary to use the instrument where 115 volt, 60 cycle power is not readily available, it may be operated from a battery power supply.

Battery power should be connected to the terminal board, TB1, as indicated on the schematic circuit diagram, K 90651. The brown jumper between terminals 3 and 4 on TB 1b connects the oscillator tube heater to the 6.3 volt transformer winding. For battery operation, remove this jumper and connect positive 6 volts to terminal 4, the extreme left terminal. The heater battery supply needs to supply only 150 ma.

The red jumper between terminals 1 and 2 on TB 1a connects the internal B+ supply to the oscillator. For battery operations, remove the jumper and connect positive 67 to 135 volts to terminal 2, the terminal second from right.

The center terminal is ground and should have A-negative and B-negative connected to it. The cable connecting the battery power supply to the Grid-Dip Meter should be fed through the hole provided in the left side of the cover. This hole is normally covered with a plug button.

The FIL. and PLATE switches on the front panel control the battery supply as well as the a-c supply.

V. GROUND

The power cable on the 90661 Industrial Grid-Dip Meter is a three wire cable with a ground lead. The Grid-Dip Meter should be

connected to a point of zero potential (ground) whenever the unit is used in the vicinity of equipment on which high voltage is applied.

VI. MAINTENANCE

The entire unit is built on a single frame, therefore the cover on three sides may be removed simply by removing the four screws on the bottom.

If the unit does not operate, as indicated by lack of meter reading, check first to be sure a coil is plugged into the coil terminals, and

second check the fuse. If the fuse is defective check for short circuit in B+ or heater circuit before replacing fuse. Do not replace fuse with a fuse larger than 1½ amperes.

It is normal for the meter to read a very slight amount when the filament is turned on and the plate is turned off.

VII. LOW FREQUENCY USE

If it is desired to use the No. 90661 or No. 90651 at frequencies below 1.7 megacycles, the following additional coils may be procured:

No. 46702	925 to 2000 kc.
No. 46703	500 to 1050 kc.
No. 46704	325 to 600 kc.
No. 46705	220 to 350 kc.

At low frequencies, below about two megacycles, coupling is a little more difficult than

at higher frequencies due to the geometry of the coil.

The Grid-Dip-Meter coil should be held near an **unloaded** tuned circuit. The Grid Dip Meter coil should be approximately **coaxial** with the coil under test. **Slowly** tuning the Grid Dip Meter with one after another of the coils should locate a sharp dip at the resonant frequency of the tuned circuit under test. **Close coupling** and **careful alignment** of the Grid Dip Oscillator coil with the coil under test will show a sharp dip in meter reading at the resonant frequency.

VIII. COILS

Seven protected coils are supplied with the unit. The color-code on the coil base corres-

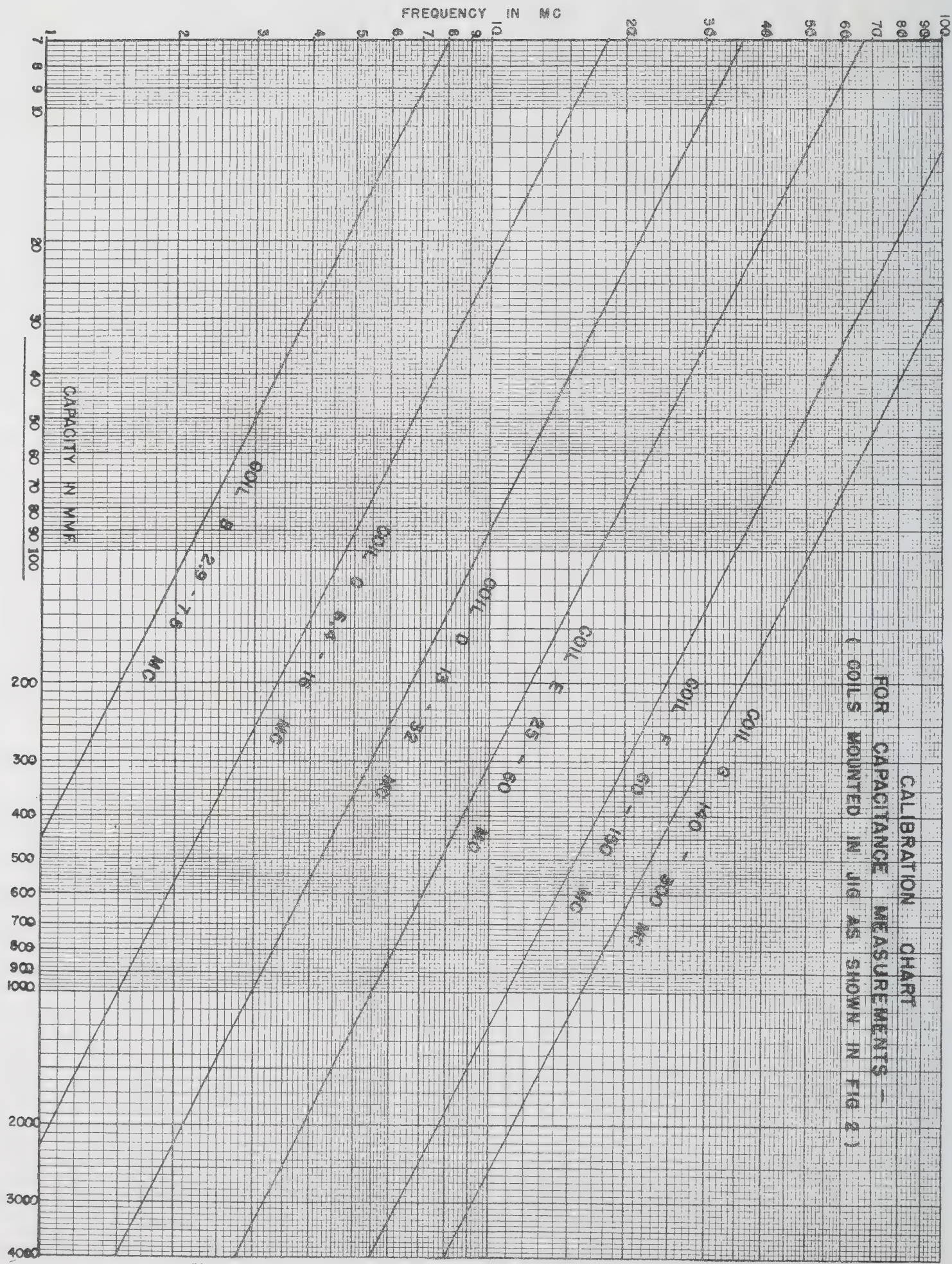
ponds with the color code on the calibrated scale.

IX. TECHNICAL SUMMARY

Frequency Range: 1.7 to 300 megacycles in seven ranges with large over lap.

Size: 7 inches x $3\frac{3}{16}$ inches x $3\frac{3}{8}$ inches (less coils).

Weight: $3\frac{1}{2}$ pounds.



CALIBRATION CHART
FOR CAPACITANCE MEASUREMENTS -
(COILS MOUNTED IN JIG AS SHOWN IN FIG 2)

2

2000

1500

1000

900

800

700

600

500

400

300

200

FREQUENCY IN KILOCYCLES

CALIBRATION OF LOW FREQUENCY INDUCTORS

FOR JAMES MILLEN 90651 OR 90661

GRID DIP METER

NO. 46702 925 TO 2000 KC.

NO. 46703 500 TO 1050 KC.

NO. 46704 325 TO 600 KC.

NO. 46705 220 TO 350 KC.

JAMES MILLEN MFG. CO., INC.

1-31-50

DIAL

10

9

8

7

6

5

4

3

2

0

2

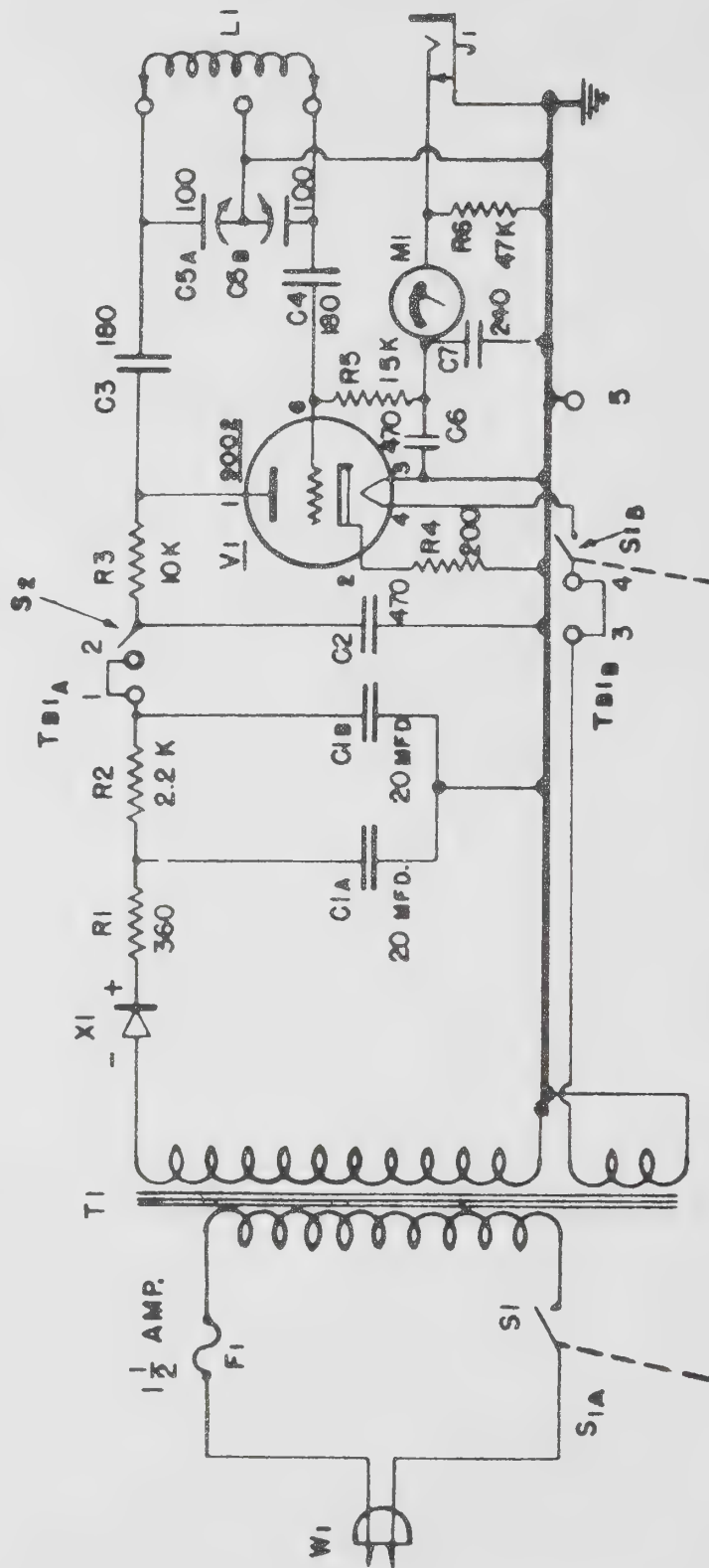
4

6

8

10

THIRD ANGLE PROJECTION



ALL CAPACITIES IN MMFD. EXCEPT WHERE NOTED
K DENOTES 1000 OHMS

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

GRID-DIP METER

FIRST MADE FOR

DESIGNED BY
DRAWN BY H. COTTERLY JR.

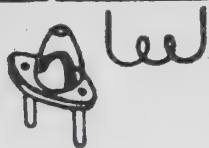
CHECKED BY P.W.C.
APPROVED

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K90651

DATE
8 - 24 - 49

1-2050 1 Added C7



HIGH FREQUENCY
HAIRPIN COIL COUPLED
AT SIDE.

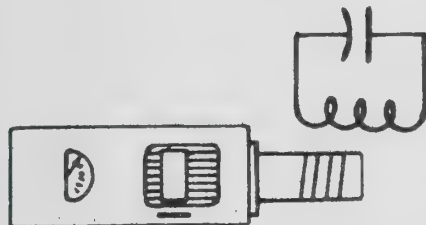
(A)



(F)

CAPACITANCE

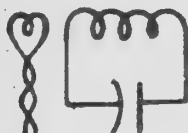
(B)



(G)

$\frac{\lambda}{4}$

(C)

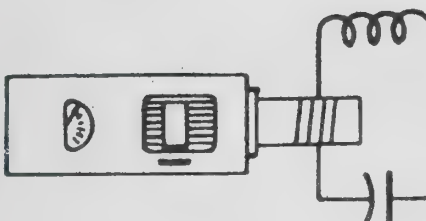


(H)

SHORT

COAX

(D)



(I)

$\frac{\lambda}{2}$

OPEN LINE

(E)



NOTE :

PROPER METHODS OF COUPLING THE
GRID - DIPPER TO CIRCUITS UNDER TEST.

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (I)

FIRST MADE FOR

DESIGNED BY
DRAWN BY H. COTTERLY

CHECKED BY R.W.C.
APPROVED

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K

DATE
5 - 3 - 49

APPENDIX I

EQUATION

"A"

$$Q = \frac{Fr}{\Delta F}$$

EQUATION

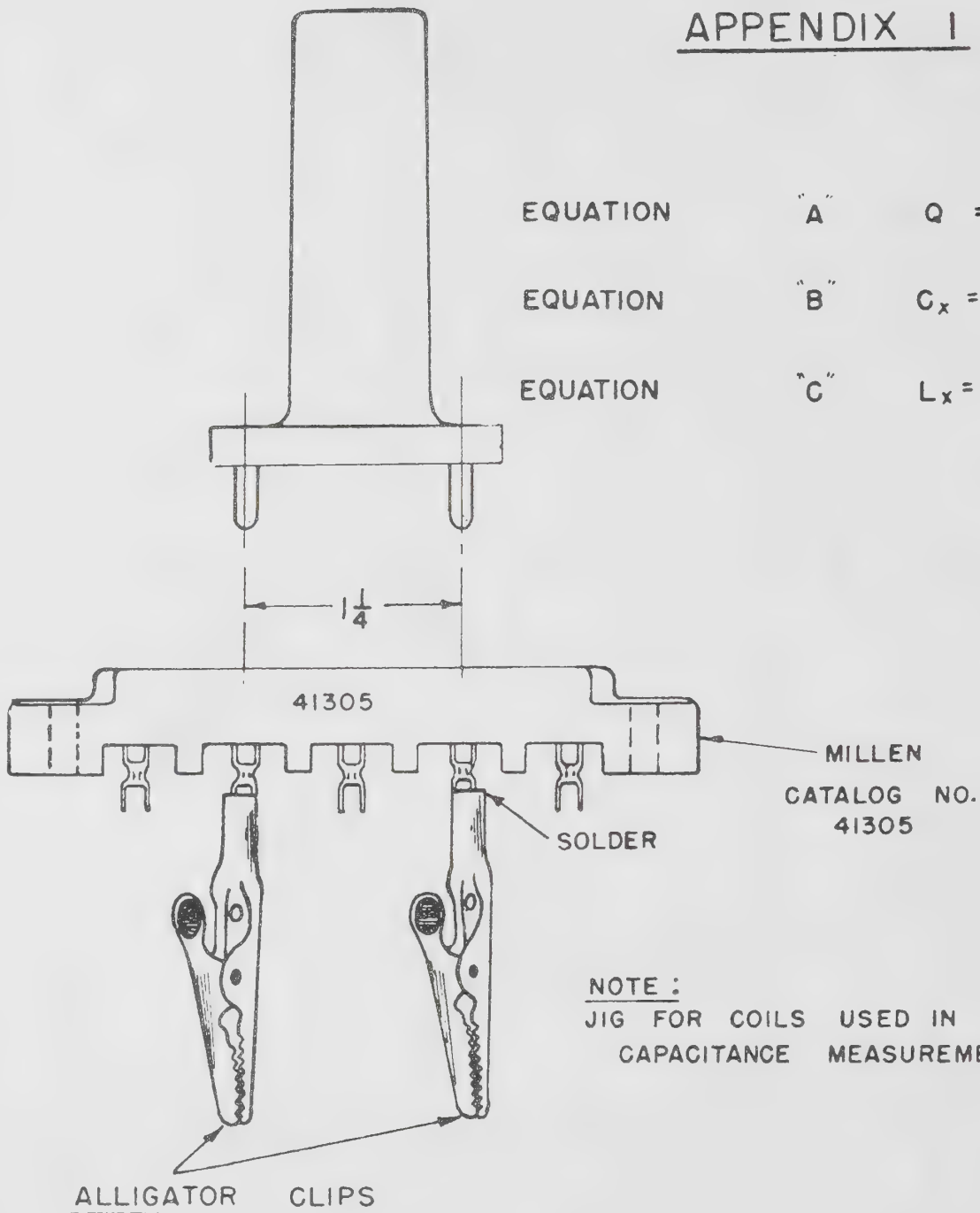
"B"

$$C_x = \frac{1}{4 \pi^2 F^2 L}$$

EQUATION

"C"

$$L_x = \frac{1}{4 \pi^2 F^2 C}$$



ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (2)

FIRST MADE FOR

DESIGNED BY
DRAWN BY H. GOTTERLYCHECKED BY R.W.C.
APPROVEDJAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K

DATE

5 - 3 - 49

GRID-DIP METER FOR RAPID TV CHECKS

Because of its light weight and small size, the versatile grid-dip meter is a useful instrument for servicing or preliminary checking of tv receivers in the home. In many cases, it may be used by itself to make quick checks that would ordinarily require the use of a sweep generator, a marker generator, and an oscilloscope.

Description

The particular instrument used in this series of experiments was the Millen Grid-Dip Meter No. 90651, which is typical of its kind. It includes a tuning dial, a meter, an ON-OFF switch for plate voltage, a set of plug-in coils for use over different ranges, and a coupling probe. This version of the grid-dip meter uses seven plug-in coils for the seven corresponding ranges calibrated on the tuning dial; it may be adjusted to any frequency from 1.7 to 300 mc. The probe consists of a length of shielded wire terminating in a single loop at one end and a double loop at the other. The two-turn loop is fitted over the plug-in coil chosen for use. The single-turn loop is injected into circuits under examination.

Applications

The meter was used successfully for checking alignment and operation of the oscillator and mixer circuits in the front end of a typical tv receiver; for checking individual alignment of i-f coils, traps, and other adjustable resonant circuits; and for injecting markers on response curves. Specific instances of the grid-dipper's use are given here to illustrate the techniques involved.

Testing TV Local Oscillators

Where a raster is present on the picture-tube screen of a receiver, but a picture cannot be obtained on any channel, the signal circuits (r-f, i-f, and video-amplifier sections) are suspect. If the video-amplifier and i-f sections are found to be normal, examination is directed to the front end. It may be that the local oscillator is inoperative or adjusted to the wrong frequency.

To check this, the receiver is set up, with a sweep generator and oscilloscope, for obtaining the over-all (r-f and i-f) response curve in accordance with the set manufacturer's instructions. In this case, the scope was connected across the video-detector load resistor, and the sweep generator was connected to the receiver's antenna-input terminals. A 4.5-volt battery provided override bias in the agc line. Its negative lead was connected to the line; the positive pole was grounded to the chassis. Both the receiver and the generator were adjusted to the same channel. In this case, the receiver was tuned to channel 6 and the generator was accordingly adjusted to sweep 6 mc across the channel-6 bandwidth (82-88 mc). A straight-line horizontal trace appeared on the scope when an attempt was made to obtain an over-all response curve.

The grid-dip oscillator was then set up as a substitute for the local oscillator in the front end, as follows: The video i.f. for this receiver is given as 21.75 mc. The video carrier for channel 6 is 83.25 mc. The correct frequency for the local oscillator, when tuned to channel 6, is therefore the sum of these, or 105 mc. With the appropriate plug-in coil in place, the grid-dipper's tuning dial was set to 105 mc. With the two-turn loop of the probe placed over the plug-in coil, a substitute oscillator signal was injected into the front end by placing the single-turn loop directly over the oscillator tube. With this arrangement, the response curve shown in Fig. 1 was obtained. Markers were placed on the curve 5 mc apart to show bandwidth. When the grid-dip oscillator was turned off, the response curve disappeared, proving that the trouble existed in the oscillator circuit.

With the receiver's local oscillator restored to normal functioning, the response curve obtained was identical to that shown in Fig. 1. It is interesting to note that the same check can be made in the home, with an active transmission and the picture tube substituted for the sweep generator and oscilloscope. With the grid-

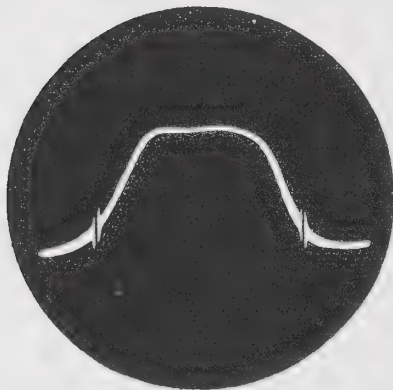


Fig. 1

dipper substituted for an inoperative local oscillator in the arrangement already described, and the receiver tuned to an operating channel, useful picture and sound is reproduced. Picture and sound quality should not always be expected to match that obtainable when the receiver is operating properly. However, the fact that any signal can be intelligibly reproduced by the injection of a substitute oscillator signal, while none appears when the grid-dipper is turned off, is sufficient to localize the fault definitely.

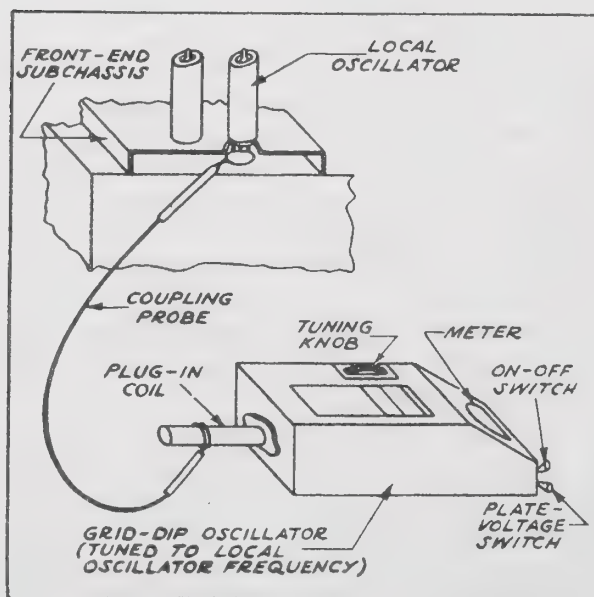


Fig. 2

This technique for substituting the local-oscillator signal was tried out on all standard tv channels. It was found to work successfully, as described, over the low band (channels 2 to 6). To obtain sufficient output for channels 7 to 13, the single-turn coupling link had to be removed from the oscillator tube itself and placed near components in the tube's circuit, underneath the front-end subchassis. This arrangement is illustrated in Fig. 2.

An alternate method may be used to check the local oscillator without the use of sweep generator or oscilloscope. In this technique, the grid dipper is also connected as shown in Fig. 2. The plate-voltage switch, however, is thrown to the OFF position, changing the instrument from an oscillator to an absorption device. The receiver is tuned to the channel to be tested and the dipper is set to the appropriate oscillator frequency. If the oscillator is operating and in proper adjustment, it will radiate energy into the coupling link of the grid-dipper. This will be shown by deflection on the instrument's meter. If there is no such indication, either the local oscillator is not functioning or it is operating at the wrong frequency.

Local-Oscillator Alignment

If the latter condition is the one that exists, the local oscillator can be retuned with a fair degree of accuracy with the aid of the grid-dipper. The grid-dipper must remain tuned to the correct oscillator frequency. The local-oscillator coil is then aligned for a peak on the grid-dip meter. In some cases, this peak will be rather broad, maintaining itself over a considerable range of adjustment of the oscillator coil. This can be counteracted by reducing coupling from the oscillator. The coupling link is moved away from the oscillator components until a sharp peak can be tuned on the oscillator coil.

Checking Alignment of I-F Coils

When a receiver is suspected of having a misaligned i-f strip, the grid-dipper is also useful for a reasonably close check of individual coils. The single-turn coupling loop is placed over the coil to be checked in the arrangement illustrated in Fig. 3. The test is conducted with the grid-dipper operated as an

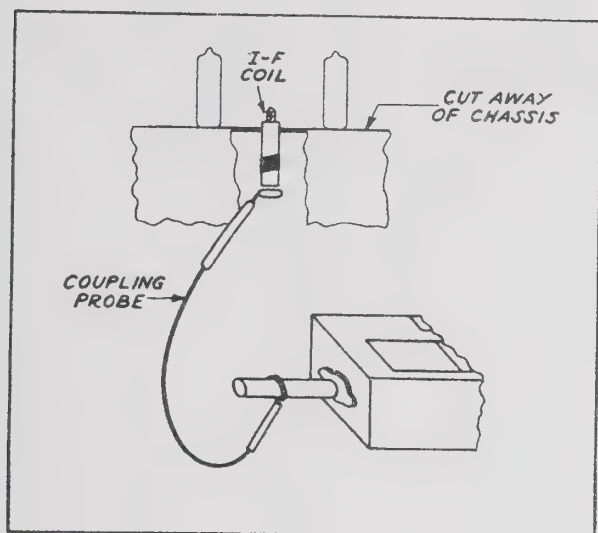


Fig. 3

oscillator (the plate-voltage switch in the ON position) and with receiver power turned off. A plug-in coil is chosen that will permit the grid-dip oscillator to be tuned through the range of frequencies over which the i-f coils should be normally adjusted. The grid-dipper tuning control is then rotated for *minimum* indication on the grid-dip meter. At this point, the reading on the tuning dial is the actual resonant frequency of the i-f coil assembly.

The i-f coil itself may then be aligned to its approximate frequency, if it is found to be mistuned. This is done by setting the grid-dip oscillator's tuning control to the desired alignment frequency and adjusting the tuning slug or trimmer on the i-f coil assembly for a dip, or minimum indication, on the grid-dip meter. A similar procedure may be employed to adjust sound traps or other traps in the video-signal portions of the receiver.

Checking Video-Amplifier Bandwidth

The grid-dipper, operated as an oscillator, also makes a handy marker generator. As such, it may be used to run a marker across a response curve to check correct placement of alignment points along the curve or to determine bandwidth.

It was tested in this capacity with a typical video-amplifier response curve, obtained with a sweep generator adjusted to sweep 0 to 10

mc, a crystal-detector probe, and an oscilloscope. The typical arrangement of these instruments is given in greater detail in CIRCUIT GUIDES III-1 and III-2. The response curve thus obtained is shown in Fig. 4.

The plug-in coil that provided the lowest range was then inserted into the grid dipper, which was tuned to 4 mc. Marker coupling was achieved by holding the probe's coupling link near components in the video-amplifier circuit. The curve thus marked appears in Fig. 5. Marker amplitude could be controlled easily by moving the probe closer to or away from the circuit components. When the grid-dipper's tuning dial was run down to 2 mc, the marker moved to the position shown in Fig. 6.

Although the grid-dip meter is a handy and valuable instrument, its accuracy, although

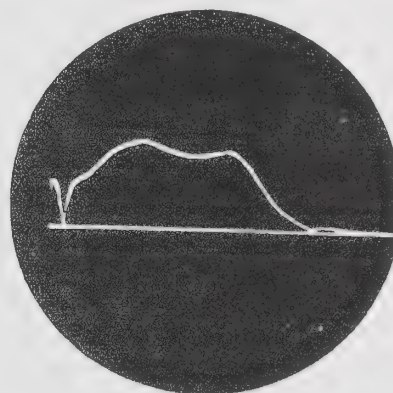


Fig. 4

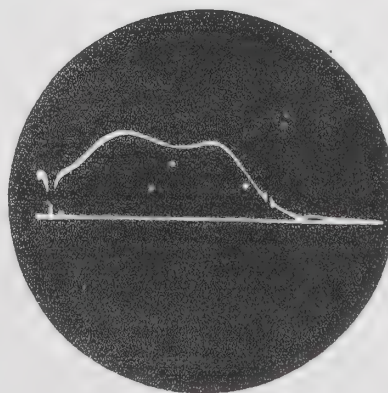


Fig. 5

TELL-A-FAULT Use of Test Equipment

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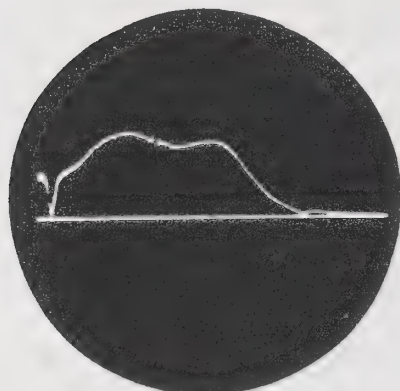
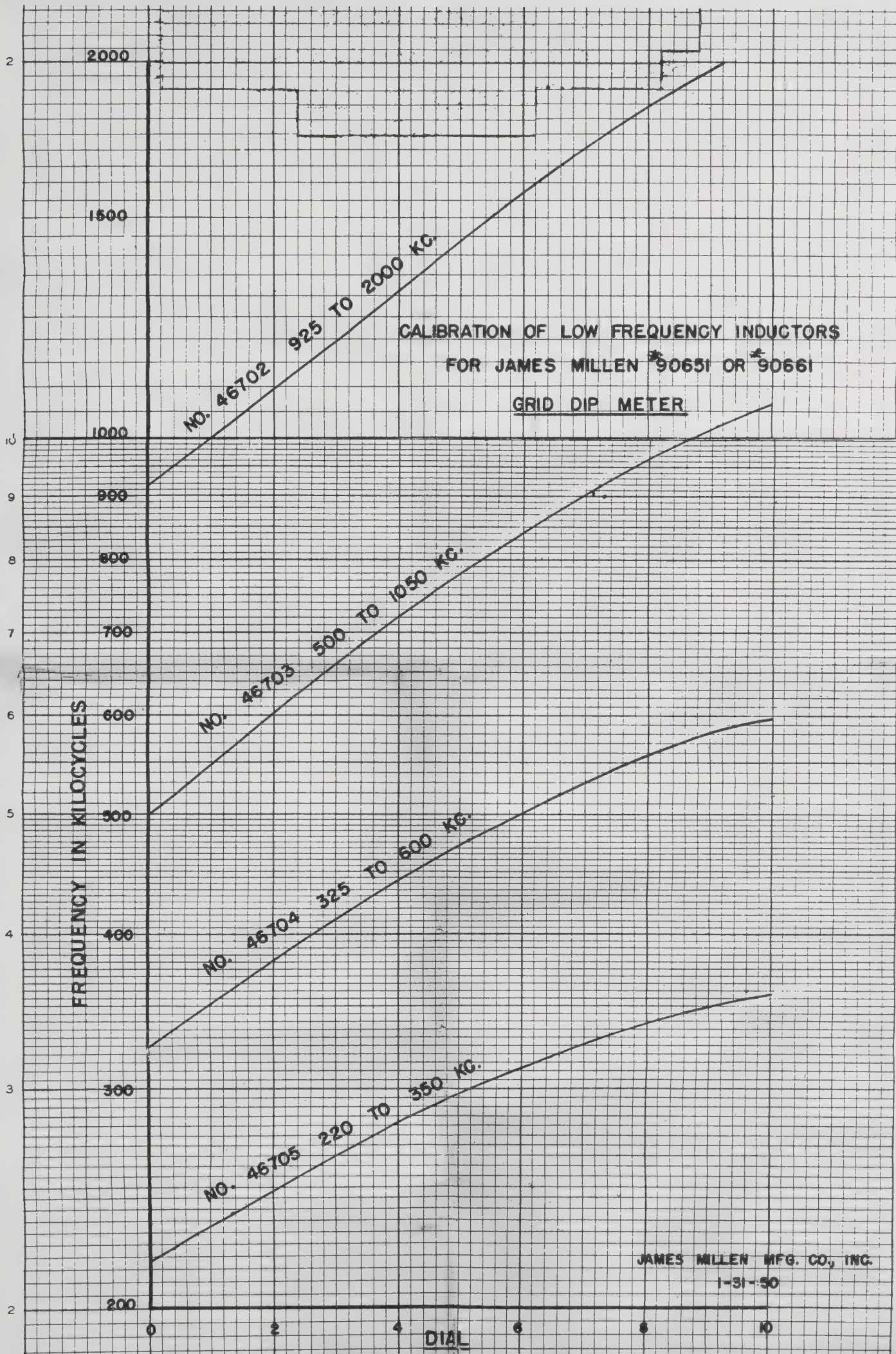


Fig. 6

very good, does not compare with that of a crystal-calibrated generator. The tests described here will give an approximate check of frequency adjustment and alignment; where greater accuracy is required, standard alignment procedures must be followed. However, since the grid-dipper may be used to determine whether such alignment is or is not necessary, even in such cases there is much saving of time in the needless setting up of test equipment for alignment where the set-up is not needed.



No. 90651 GRID-DIP METER

I. GENERAL

The Millen 90651 Grid-Dip Meter may be used in any of the following manners:

1. **Grid-dip oscillator** for use as an oscillating frequency meter to determine the resonant frequency of de-energized r. f. circuits.

Plate potential is applied to the Grid-Dip Meter and it becomes an r. f. oscillator. A d.c. meter in the grid return indicates relative power. When a circuit, resonant at the oscillator frequency, is coupled to the "probe" inductance, power is absorbed from the oscillator by the resonant circuit and is so indicated by a dip (decrease) in the grid meter reading. The "Grid Dipper", employed in this manner, may then be used to check the resonant frequency of a circuit **without the application of power to the circuit in question**. This results in a considerable saving of time, and a definite assurance of correct frequency adjustment of a circuit is obtained. Circuits may be checked or pretuned before completion of the unit in which they are to be used. Only minor trimming is generally required under actual operation. Guesswork or "cut and try" methods are eliminated. Possible damage to components during initial tune up and adjustment is eliminated.

2. **Oscillating detector** for determining the fundamental or harmonic frequencies of energized r.f. circuits.

Plate potential is applied and the instrument is used as an r.f. oscillator. Instead of observing the grid-meter reading, a pair of phones is inserted in the phone jack and an audible beat may be heard when the instrument is tuned to the fundamental or harmonic frequency of a source of r.f. The frequency may be read directly from the calibrated dial.

3. **Signal generator**. The instrument may be employed for this purpose generally in place of a standard signal generator, except where special shielding or a known r.f. output voltage is required.

4. **Tuned r.f. diode or non-oscillating detector** for use as an absorption-type frequency meter. No plate potential is applied and the internal tube is used as a diode. The grid meter is then in the diode load circuit and will read up-scale (current increase) when the instrument is tuned and closely coupled to a source of r.f. energy.

II. METHODS OF COUPLING

Correct methods of coupling the grid-dip meter to circuits under tests are shown in Fig. 1. When used as a grid-dip oscillator harmonics of lumped-constant resonant circuits will not be indicated; however, other resonant frequencies are sometimes indicated. These will be due to other resonant circuits formed by circuit wiring, stray capacitances, etc. In most cases these will occur at a higher frequency. On the other hand, harmonics of antennas, transmission lines, etc. will be indicated as will be explained later in the text under the heading "antennas."

When looking for the grid dip, it will be noted that the grid current reading slowly varies as the dial is rotated; however, correct resonance is indicated when the meter takes a sharp or pronounced dip.

It is suggested that the user of the "Grid Dipper" at first set up test L/C combinations, short test antennas, etc., and check them with the instrument in order to become familiar with the coupling methods and with the general behavior and operation of the unit.

Coupling too tightly will cause a deep sharp dip and a sudden rise. This tight coupling pulls the oscillator frequency somewhat, and makes it difficult to determine the resonant frequency. Over-coupling will cause inaccuracy in determining the resonant frequency. The solution is to back the Grid Dip Meter away from the test coil until the dip is barely perceptible. With this coupling there is no difficulty in determining the resonant frequency and the measurement will be accurate.

III. APPLICATIONS

Receiver tuned circuits. Use the instrument as a grid-dip oscillator. Remove power from the receiver and resonate each tuned circuit to the desired frequency as indicated by the meter dip. Gang tuned circuits should

be aligned for tracking by checking at each end of the ganged range. A check at one or two points in between will also be helpful. Methods of electrically obtaining the desired bandspread or tracking will not be explained

here. Reference may be made to any good radio text book.

Following the above procedure, power may be applied to the receiver and the grid-dip meter employed as a signal generator for checking final alignment. A very short antenna should be connected to the receiver input terminals and the "Grid Dipper" should be placed on the bench removed from nearby conductors, and where body movements are least apt to affect the r.f. signal from the instrument. Some sort of indicating device such as an "S" meter or v.t.v.m. at the receiver detector must be used. If the r.f. signal is too strong, the receiver antenna may be shortened, or the instrument may be removed to a more remote or partially shielded location.

Where a superheterodyne type of receiver is involved and, if the receiver fails to function, it is quite possible that the receiver local oscillator is not working. This may be checked by employing the "Grid Dipper" as an r.f. diode detector or absorption type wave meter. Couple it to the oscillator coil and, if the meter does not go up-scale when the instrument is tuned to the resonant frequency of the oscillator tank, the oscillator is not functioning. An alternative method having greater sensitivity and capable of more accurate frequency measurement is to use the instrument as an oscillating detector and listen for the local oscillator beat in the headphones.

Transmitter tuned circuits. Use the instrument as a grid-dip oscillator with plate power removed from transmitter and proceed to adjust tanks to desired frequency as with receiver circuits. Tubes should be in place, and where capacitive coupling is used between stages, the grid circuit associated with following tube should be completed.

After the above procedure, plate power may be applied and final alignment made according to grid and plate meter indications. R.f. power at correct frequency in each tank may be checked by employing the "Grid Dipper" as a diode absorption frequency meter or it may be utilized as an oscillating detector. Due to its greater sensitivity in the latter state, care must be taken not to mistake audible beats from some other energized r.f. circuit. This may be checked by moving the instrument closer to the circuit under test and noting whether or not the beat increases in volume. If it does, the beat heard is from the desired circuit. Harmonics also may be heard, so it is wise to check for the beat heard at the lowest frequency.

Neutralization. Employ the instrument as a grid-dip oscillator. Remove all plate power from the transmitter. Couple the "Grid Dipper" to grid tank of stage to be neutralized, or in the case of capacitive coupling to the preceding plate tank (it is assumed that the tank has already been tuned to correct frequency). Couple fairly close and leave instrument set in position with its meter deflected at bottom of the resonant dip. Neutralization is then indicated when rotation of amplifier plate tank capacitor has no reaction on the deflected meter reading. Another method is to use the instrument as a diode absorption-type meter and proceed to neutralize in the manner normally employed when using absorption-type wavemeter, or as with similar indicating device, i.e.:

Remove plate power from amplifier stage to be neutralized, and apply power to stage driving the grid. Couple the "Grid Dipper" to the amplifier tank, tune the instrument to the driving frequency and check for the presence of r.f. in the tank as indicated by a rise in the "Grid Dipper" meter current. Adjust neutralizing capacitor until no reading is seen on the meter.

Parasitic oscillations. Apply power to transmitter and use instrument as an oscillating detector while listening on headphones for beat of parasitic oscillation. As an alternative, the parasitic frequency may be determined by using the instrument as a tuned r.f. diode or absorption type frequency meter. When parasitic frequency has thus been determined, as read from the "Grid Dipper" scale, remove power from transmitter and use instrument as a grid-dip oscillator to locate circuits or components, such as r.f. chokes, circuit wiring, etc., resonant at parasitic frequency.

Parallel resonant traps. Use as a grid-dip oscillator. Trap may be tuned or checked either before or after connecting it in desired circuit. If tuned before installation, adjustment will remain correct upon installation if its inductance is physically removed from other conductive components which may alter the inductance value. This is not usually the case, so further minor adjustment will probably be required after installation. When in the circuit, it is possible that its resonant frequency may be quite a bit off as indicated by the "Grid Dipper". Actually the trap itself will still be tuned to approximately correct frequency but the grid-dip oscillator reading may be found at some other frequency (usually lower) due to circuit "strays" across the trap.

Final precise adjustment may be made by applying power to circuit and by tuning trap under actual operation for desired effect. In many cases this will not be necessary as pre-tuning is quite accurate.

Series resonant traps. Follow same general procedure as with parallel resonant trap. To check or tune prior to installation, trap may be first connected as a parallel trap. At high frequencies or where the trap inductance is low, the lead completing the parallel circuit should be of large wire or wide copper ribbon to keep its inductance low, and care should be taken not to permit this lead to be positioned so as to add stray capacitance. Leads to be used upon final installation must also be included when external measurements are being made.

R. F. chokes. To determine self resonance of r.f. chokes, use "Grid Dipper" as a grid dip oscillator.

Measure circuit Q. Use the "Grid Dipper" as signal generator. Connect a v.t.v.m. across the circuit to be measured. Couple instrument to circuit (Fig. 1A) and resonate for maximum, or peak reading, on v.t.v.m. Note frequency at which this occurs. Then shift the instrument each side of resonance to the frequency where the voltmeter reading drops to approximately 70.7% of that at resonance. Note the frequency of these two points and calculate the circuit Q from equation "A", Appendix 1, where f_r is the resonant frequency and Δf is the difference between the "off resonance" frequencies just found. The original coupling should be adjusted for a convenient maximum reading of the v.t.v.m. and then should be left fixed at this position for the remainder of the procedure.

When the circuit Q is quite high, it may be necessary to check the frequencies with a calibrated receiver, because the "off resonance" points will occur too closely together for accurate reading on the instrument scale.

Relative circuit Q at a given frequency. Use as a grid-dip oscillator and observe character of the dip whether broad or sharp. The sharper the dip, the higher the Q.

Measurement of capacitance. Several methods may be employed. All involve the use of the "Grid Dipper" as an oscillator.

A small jig (Fig. 2) must be made, into which may be plugged any one of the "Grid Dipper" coils.

To check an unknown capacitor, it is then only necessary to clip the jig, with a coil inserted, across the unknown capacitance. Find the resonant frequency and refer to the calibration chart for value of capacitor with the coil employed. For over-all accuracy, it is best to employ one of the coils from the medium frequency range.

Due to the distributed capacitance of the coils, a slight error will be encountered at very low capacitance measurements. Likewise, due to self inductance of large capacitors, a small error will be found when measuring these. Errors will be negligible for most practical purposes.

Measurements below 50 mmf are generally not obtainable because resonance at these values usually falls out of range of the coils left available for frequency checking. For measurements below 50 mmf an additional calibrated coil is required.

For these measurements, in a great number of cases, the capacitor need not be removed from the circuit in which it is wired unless the capacitor is heavily loaded.

Another method, similar to that above, is to employ a known inductance and find the resonant frequency with the unknown connected across it. See equation "B" Appendix 1 where f is the resonant frequency in cycles and L is the inductance in henries. C_x will be in farads.

A third method, for capacitors up to about 1000 mmf, requires an inductance which is shunted by a calibrated variable capacitor. The capacitor is set at maximum and the resonant frequency of the circuit is found. The unknown capacitor is then connected across the variable and the capacitance of the latter decreased to a point where the circuit resonates at the original frequency. The difference between the first and last settings of the calibrated variable capacitor is the value of the unknown.

Measurement of inductance of r.f. coils. Connect a capacitor of known value across the coil and use the "Grid Dipper" as a grid-dip oscillator to find the resonant frequency of the resulting L/C combination. The inductance of the coil may be calculated from equation "C" Appendix 1 where L_x is in henries, C is known capacitor in farads; or reference may be made to an L/C-resonance chart.

In measuring small values of inductance, be sure to employ a low inductance standard condenser, connected to the unknown coil by

wide ribbon, in order to obtain most accurate results. Due to the distributed capacitance, especially in large coils, some slight error will result; however, if the value of the low inductance known capacitor is fairly high, the error will be negligible.

Relative Q of capacitors or inductances at a given frequency may be noted by observing the character of the dip, as previously described.

Antennas. Use instrument as grid-dip oscillator. Coupling should be made at a low impedance or high current point as shown in Fig. 1E. This point, for a half wave antenna, is at the center, and for longer wires is at points odd quarter wavelengths measured from either end. It will be observed that a full-wave antenna will not be a half-wave at exactly half its resonant frequency. This is because the end effects are found only at the antenna ends and will be absent at other points when the antenna is a full wave or more long. It is therefore always necessary to measure an antenna under the conditions desired (relating to physical and electrical length). Measurement should be made with the antenna placed as near as possible to its ultimate operating position. Checks on a given antenna at different heights or positions will show an amazing difference in antenna resonance.

If it is physically impossible to reach a low impedance point, a check may be made at a high-impedance or high-voltage point. Capacitive coupling should be used as shown at Fig. 1F. If the high impedance point involved is one of the ends, the end effect will be altered due to the presence of the instrument and the resonant frequency of the antenna will slightly decrease. This must be taken into consideration when making measurement, i.e., the reading indicated will be slightly lower than true antenna resonance (with "Grid Dipper" away from end). This difference will be about 1 to 3% and will be encountered only when checking at the ends.

In all cases it is helpful to keep in mind the physical length in feet vs. electrical length (half-wave, full-wave, etc.) as calculated approximately by formula. Unlike lumped resonant circuits, antenna harmonics are detected when using the "Grid Dipper." As previously mentioned, these harmonics will not occur at exact multiples of a half-wave.

When measurement is made, the feeders should be disconnected from the antennas. Unless the feeders happen to be perfectly

matched or terminated, true antenna resonance will not be indicated because unmatched feeders or incorrectly terminated feeders will present either a positive or negative reactance and will, therefore, alter the electrical length of the antenna.

When the antenna element is of very large diameter, such as is often found in rotating beams, sufficient coupling to the "Grid Dipper" may not be obtained and some difficulty will be encountered in finding a reading. This condition may sometimes be relieved by jumping a foot or so of the antenna at the center with a small diameter wire and coupling to this wire.

If the antenna is to be normally used with its center open, close it with the shortest possible wire during measurement. This must be done also with the folded dipole. The short may later be removed, if required, when feeders are connected.

Tuned or resonant feeders, such as used in the Zepp antenna. Use instrument as grid-dip oscillator and check for desired resonance at the series or parallel tuned circuit on the transmitter end of the feeder. If resonance at the desired frequency is not obtainable, alterations may be made in the tuned circuit or the feeder length according to the actual resonant frequency found. Care must be exercised not to become confused by other resonance indications. It must be remembered that a Zepp is actually a long wire antenna partially doubled back on itself and resonance can therefore be noted at frequencies both higher and lower than the desired one.

Untuned or non-resonant feeders. After the antenna has been adjusted to the correct length, an untuned feed line may be connected employing some system of matching. Correct match may be obtained by making adjustment while employing a transmission impedance bridge or a standing-wave-ratio meter and using the "Grid Dipper" (set at antenna resonant frequency) as the signal generator.

The transmission bridge or the s-w-r meter should employ a meter of full scale sensitivity of 200 ua or less, for most accurate readings. Coupling to the "Grid Dipper" should be as loose as possible consistent with obtaining sufficient reading. If the coupling is too tight, the instrument frequency calibration may be slightly shifted.

The matching device should then be adjusted for as near unity standing-wave-ratio as

possible. If a satisfactorily low standing-wave-ratio is unobtainable, it is due to either a fault in the matching system or due to a shift in antenna resonance. The latter may be checked by slightly varying the "Grid Dipper" frequency until a lower s.w.r. is found or until a better s.w.r. meter null is indicated. The frequency at this point will be that of antenna resonance. If necessary, the antenna length may then be changed until the correct standing-wave-ratio is realized at the desired frequency. It may also be necessary to trim up the adjustment of the matching system.

Tuning the parasitic beam. Use the instrument as grid-dip oscillator and adjust driven element for resonance. The feeder should be disconnected and the parasitic elements should be set at their calculated correct length. If the driven element is open at the center, close it. After this element has been properly set, connect and match feeder as described in the foregoing paragraph (open antenna center if matching system so requires). The parasitic elements may then be adjusted using the "Grid Dipper" as the signal generator coupled to the feed line and by observing readings on a receiver (with an "S" meter) connected to a short antenna some distance away. Relative field readings in actual "S" units then may be obtained after each adjustment. As when matching feeder, coupling to the "Grid Dipper" should be as loose as possible. It is a good idea to occasionally check the actual frequency of the instrument on the receiver.

Following the tuning of the parasitic elements, the standing-wave-ratio should again be checked. It will, undoubtedly, increase, because tuning of the other elements will cause a change in antenna resonance. This will have to be altered accordingly, as described under "matching of non-resonant lines." Repetition of the preceding steps is advisable for putting on the finishing touches.

If the beam is located so that surrounding objects are likely to cause detuning as the beam is rotated (this may be checked during antenna and parasitic element tuning), it may be advisable to do the final retuning with the beam positioned either towards the direction in which it will be mostly used, or where the greatest degree of rotation has the least effect.

Needless to say, the transmitter may be used as the signal generator in place of the "Grid Dipper" during the above adjustments; however, the employment of the "Grid Dipper" for this purpose is more convenient, because the entire operation may be handled right on

the roof by one person, or wherever the beam is located. The use of the instrument also keeps the channel free from unnecessary QRM.

Quarter-wave shorted lines. Use as a grid-dip oscillator and couple for open wire lines as at Fig. 1G, and for coaxial lines as at Fig. 1H. When trimming lines for correct length, fittings to be used eventually for connections should be installed on the end of the line. The approximate frequency of the line may be determined by rough calculation. Other resonant points can be found, however. These will be at three times the fundamental quarter-wave, where the line is then three-quarter waves long, or five times the fundamental quarter-wave, etc.

Quarter-wave open lines. For open-wire lines, connect a short at one end and measure as for quarter-wave shorted line. Due to the length of the short, the actual electrical length of the line (used as an open line) will be slightly in error depending on the line spacing. The closer the spacing, the smaller the error.

For coax lines, place short on line and measure as quarter-wave shorted line. The short should be as direct and short as possible from inner conductor to shield in order to avoid errors. Fittings should also be included. Remove the short after measurements are completed.

Half-wave shorted lines. For open-wire lines, couple at center as shown at Fig. 1I. For coax line, measure for quarter-wave shorted line at half the calculated or desired frequency. Resonant frequency thus found must be then multiplied by 2 for a resulting half-wave shorted line.

Half-wave open lines. For open-wire lines, couple at center as shown at Fig. 1I. For coax line, short one end and measure for quarter-wave shorted line at half the calculated frequency. Resonant frequency thus found must be multiplied by 2 for the correct length of the line after short is removed; provided the short is made direct as mentioned above.

Check standing waves. Aside from employing the "Grid Dipper" as the signal generator in conjunction with a standing wave ratio meter, open-wire feed lines may be checked for the existence of standing waves by using the instrument as a diode detector. A flat line is indicated when the meter reading remains constant as the "probe" coil is moved along the line. Care must be used to maintain uniform

distance or coupling between coil and line. Since the "Grid Dipper" coil is protected by an insulated sleeve, the coil form may be held against the line for maintaining uniform coupling.

This method is the same as that using a neon bulb, crystal detector or other similar device.

Relative field-strength meter. Use the "Grid Dipper" as diode detector. Connect a short antenna to one of the coil posts through a 5-30 mmf capacitor. The instrument's frequency calibration will shift some, so the dial

will have to be rotated for maximum reading of the received signal. Actual frequency calibration is unimportant for this purpose. Sensitivity of the "Grid Dipper" as a field meter is not as great as that of some other devices, but it will, nevertheless, be helpful in many cases.

The "Grid Dipper" may be employed for a number of other measurements, principally when utilized as a signal generator. Its use as a grid-dip oscillator will be quite obvious and self suggestive for measurement of many other types of equipment and circuits. The applications herein described are those which will be generally most useful.

IV. POWER SUPPLY

The 90661-90651 is supplied complete with its own internal power supply. The unit will operate on 105 to 125 volts at 50 to 60 cycles per second. If it should become necessary to use the instrument where 115 volt, 60 cycle power is not readily available, it may be operated from a battery power supply.

Battery power should be connected to the terminal board, TB1, as indicated on the schematic circuit diagram, K 90651. The brown jumper between terminals 3 and 4 on TB 1b connects the oscillator tube heater to the 6.3 volt transformer winding. For battery operation, remove this jumper and connect positive 6 volts to terminal 4, the extreme left terminal. The heater battery supply needs to supply only 150 ma.

The red jumper between terminals 1 and 2 on TB 1a connects the internal B+ supply to the oscillator. For battery operations, remove the jumper and connect positive 67 to 135 volts to terminal 2, the terminal second from right.

The center terminal is ground and should have A-negative and B-negative connected to it. The cable connecting the battery power supply to the Grid-Dip Meter should be fed through the hole provided in the left side of the cover. This hole is normally covered with a plug button.

The FIL. and PLATE switches on the front panel control the battery supply as well as the a-c supply.

V. GROUND

The power cable on the 90661 Industrial Grid-Dip Meter is a three wire cable with a ground lead. The Grid-Dip Meter should be

connected to a point of zero potential (ground) whenever the unit is used in the vicinity of equipment on which high voltage is applied.

VI. MAINTENANCE

The entire unit is built on a single frame, therefore the cover on three sides may be removed simply by removing the four screws on the bottom.

If the unit does not operate, as indicated by lack of meter reading, check first to be sure a coil is plugged into the coil terminals, and

second check the fuse. If the fuse is defective check for short circuit in B+ or heater circuit before replacing fuse. Do not replace fuse with a fuse larger than 1½ amperes.

It is normal for the meter to read a very slight amount when the filament is turned on and the plate is turned off.

VII. LOW FREQUENCY USE

If it is desired to use the No. 90661 or No. 90651 at frequencies below 1.7 megacycles, the following additional coils may be procured:

No. 46702	925 to 2000 kc.
No. 46703	500 to 1050 kc.
No. 46704	325 to 600 kc.
No. 46705	220 to 350 kc.

At low frequencies, below about two megacycles, coupling is a little more difficult than

at higher frequencies due to the geometry of the coil.

The Grid-Dip-Meter coil should be held **near** an **unloaded** tuned circuit. The Grid Dip Meter coil should be approximately **coaxial** with the coil under test. **Slowly** tuning the Grid Dip Meter with one after another of the coils should locate a sharp dip at the resonant frequency of the tuned circuit under test. **Close coupling** and **careful alignment** of the Grid Dip Oscillator coil with the coil under test will show a sharp dip in meter reading at the resonant frequency.

VIII. COILS

Seven protected coils are supplied with the unit. The color-code on the coil base corres-

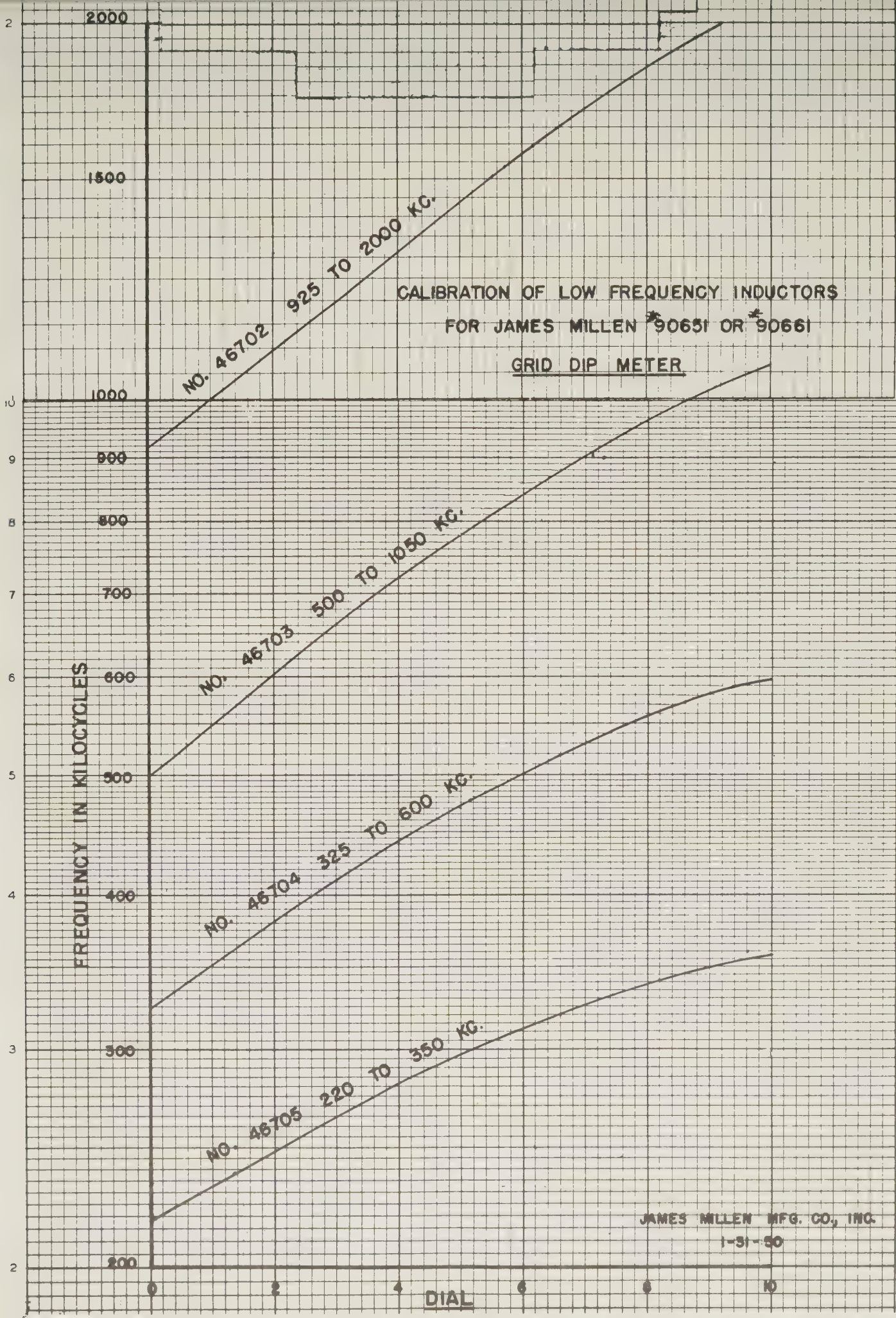
ponds with the color code on the calibrated scale.

IX. TECHNICAL SUMMARY

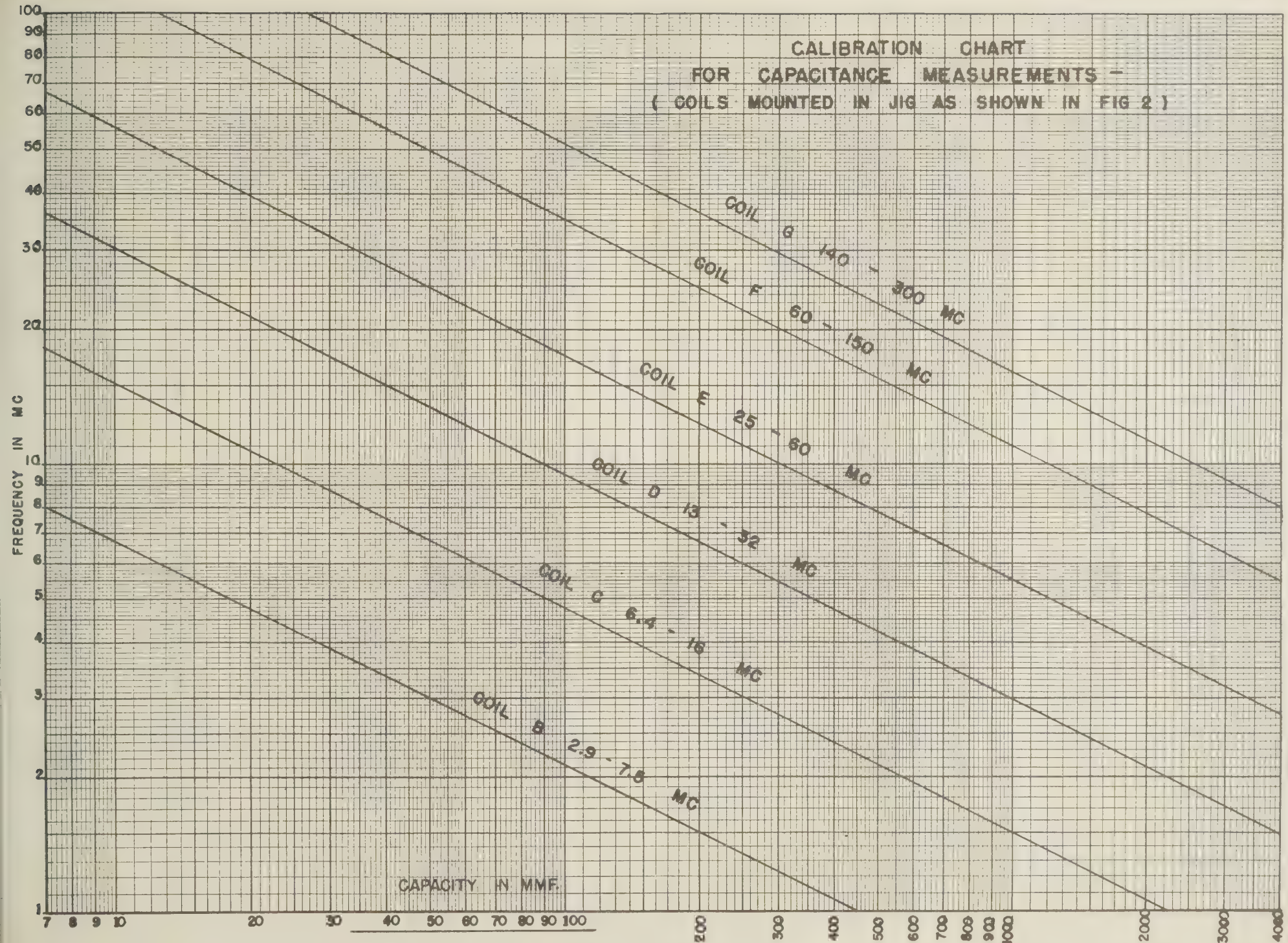
Frequency Range: 1.7 to 300 megacycles in seven ranges with large over lap.

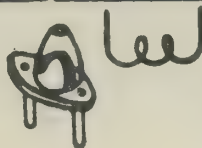
Size: 7 inches x $3\frac{3}{16}$ inches x $3\frac{3}{8}$ inches (less coils).

Weight: $3\frac{1}{2}$ pounds.



CALIBRATION CHART
FOR CAPACITANCE MEASUREMENTS -
(COILS MOUNTED IN JIG AS SHOWN IN FIG 2)





HIGH FREQUENCY
HAIRPIN COIL COUPLED
AT SIDE.

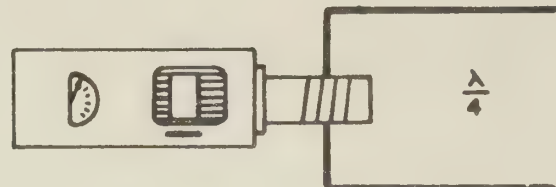
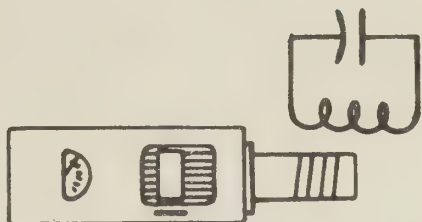
(A)



(F)

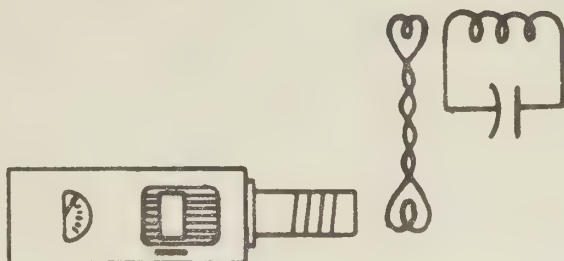
CAPACITANCE

(B)



(G)

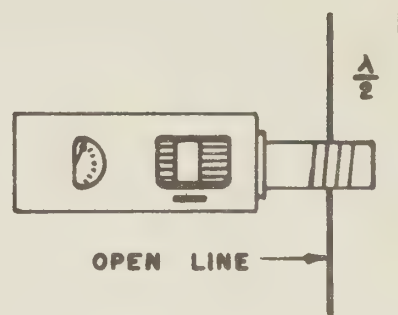
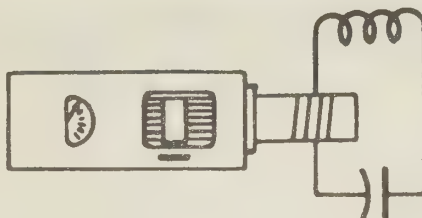
(C)



(H)

COAX

(D)



(I)

OPEN LINE

(E)



NOTE :

PROPER METHODS OF COUPLING THE
GRID - DIPPER TO CIRCUITS UNDER TEST.

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG.(I)

FIRST MADE FOR

DESIGNED BY

DRAWN BY H. GOTTERLY

CHECKED BY R.W.G.

APPROVED.

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K

DATE

5 - 3 - 49

APPENDIX I

EQUATION

"A"

$$Q = \frac{Fr}{\Delta F}$$

EQUATION

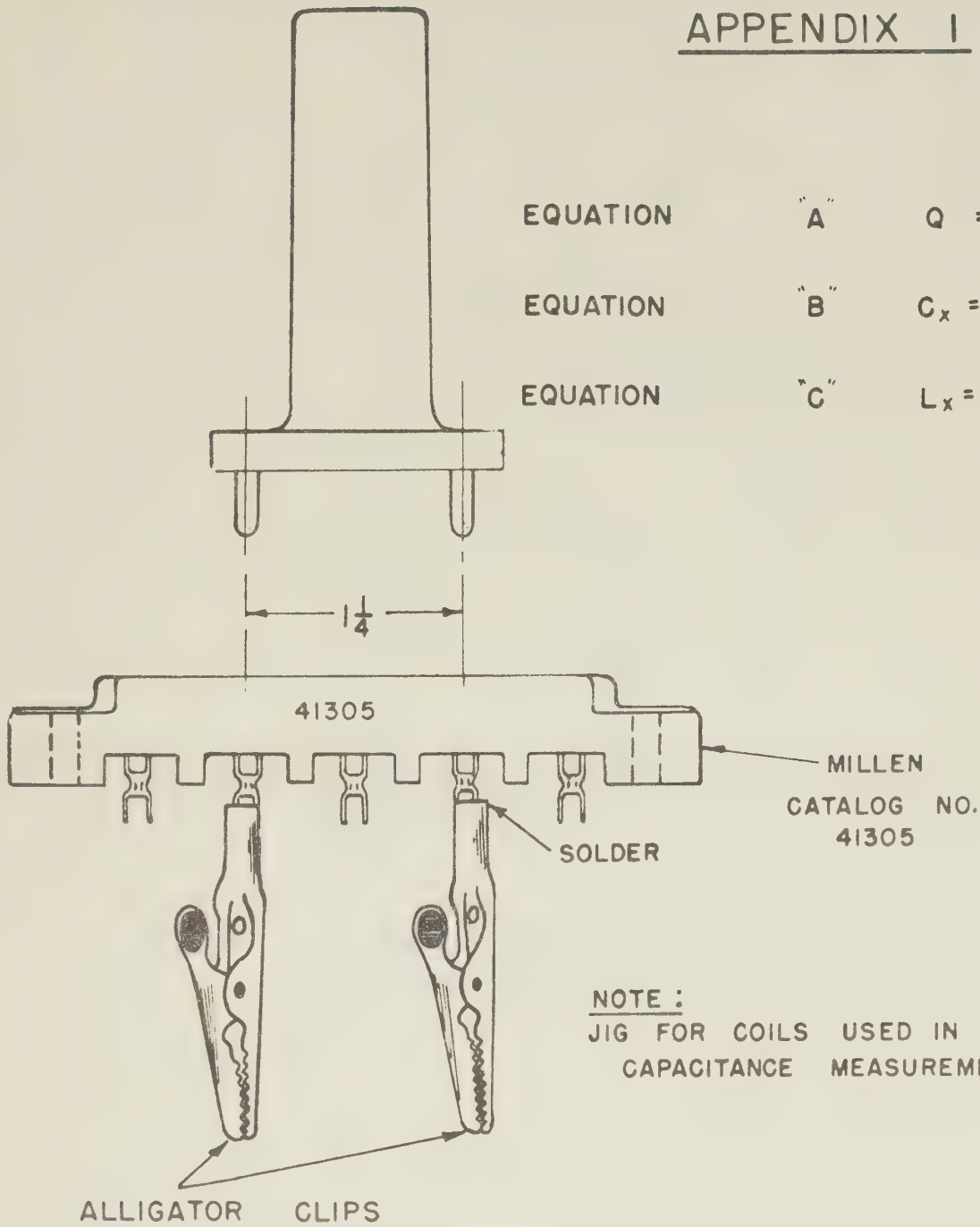
"B"

$$C_x = \frac{1}{4 \pi^2 F^2 L}$$

EQUATION

"C"

$$L_x = \frac{1}{4 \pi^2 F^2 C}$$



ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (2)

FIRST MADE FOR

DESIGNED BY
DRAWN BY H. COTTERLYCHECKED BY R.W.C.
APPROVEDJAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K

DATE
5 - 3 - 49

GRID-DIP METER FOR RAPID TV CHECKS

Because of its light weight and small size, the versatile grid-dip meter is a useful instrument for servicing or preliminary checking of tv receivers in the home. In many cases, it may be used by itself to make quick checks that would ordinarily require the use of a sweep generator, a marker generator, and an oscilloscope.

Description

The particular instrument used in this series of experiments was the Millen Grid-Dip Meter No. 90651, which is typical of its kind. It includes a tuning dial, a meter, an ON-OFF switch for plate voltage, a set of plug-in coils for use over different ranges, and a coupling probe. This version of the grid-dip meter uses seven plug-in coils for the seven corresponding ranges calibrated on the tuning dial; it may be adjusted to any frequency from 1.7 to 300 mc. The probe consists of a length of shielded wire terminating in a single loop at one end and a double loop at the other. The two-turn loop is fitted over the plug-in coil chosen for use. The single-turn loop is injected into circuits under examination.

Applications

The meter was used successfully for checking alignment and operation of the oscillator and mixer circuits in the front end of a typical tv receiver; for checking individual alignment of i-f coils, traps, and other adjustable resonant circuits; and for injecting markers on response curves. Specific instances of the grid-dipper's use are given here to illustrate the techniques involved.

Testing TV Local Oscillators

Where a raster is present on the picture-tube screen of a receiver, but a picture cannot be obtained on any channel, the signal circuits (r-f, i-f, and video-amplifier sections) are suspect. If the video-amplifier and i-f sections are found to be normal, examination is directed to the front end. It may be that the local oscillator is inoperative or adjusted to the wrong frequency.

To check this, the receiver is set up, with a sweep generator and oscilloscope, for obtaining the over-all (r-f and i-f) response curve in accordance with the set manufacturer's instructions. In this case, the scope was connected across the video-detector load resistor, and the sweep generator was connected to the receiver's antenna-input terminals. A 4.5-volt battery provided override bias in the agc line. Its negative lead was connected to the line; the positive pole was grounded to the chassis. Both the receiver and the generator were adjusted to the same channel. In this case, the receiver was tuned to channel 6 and the generator was accordingly adjusted to sweep 6 mc across the channel-6 bandwidth (82-88 mc). A straight-line horizontal trace appeared on the scope when an attempt was made to obtain an over-all response curve.

The grid-dip oscillator was then set up as a substitute for the local oscillator in the front end, as follows: The video i.f. for this receiver is given as 21.75 mc. The video carrier for channel 6 is 83.25 mc. The correct frequency for the local oscillator, when tuned to channel 6, is therefore the sum of these, or 105 mc. With the appropriate plug-in coil in place, the grid-dipper's tuning dial was set to 105 mc. With the two-turn loop of the probe placed over the plug-in coil, a substitute oscillator signal was injected into the front end by placing the single-turn loop directly over the oscillator tube. With this arrangement, the response curve shown in Fig. 1 was obtained. Markers were placed on the curve 5 mc apart to show bandwidth. When the grid-dip oscillator was turned off, the response curve disappeared, proving that the trouble existed in the oscillator circuit.

With the receiver's local oscillator restored to normal functioning, the response curve obtained was identical to that shown in Fig. 1. It is interesting to note that the same check can be made in the home, with an active transmission and the picture tube substituted for the sweep generator and oscilloscope. With the grid-

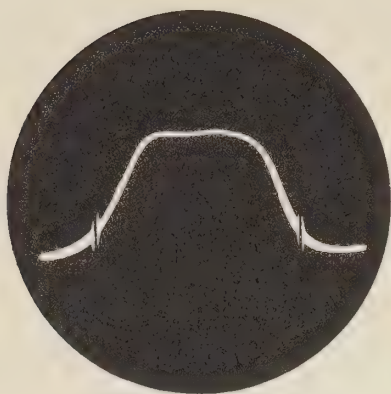


Fig. 1

dipper substituted for an inoperative local oscillator in the arrangement already described, and the receiver tuned to an operating channel, useful picture and sound is reproduced. Picture and sound quality should not always be expected to match that obtainable when the receiver is operating properly. However, the fact that any signal can be intelligibly reproduced by the injection of a substitute oscillator signal, while none appears when the grid-dipper is turned off, is sufficient to localize the fault definitely.

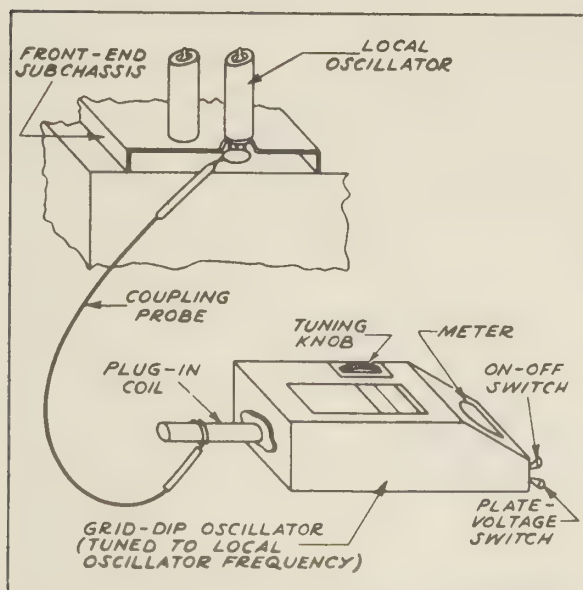


Fig. 2

This technique for substituting the local-oscillator signal was tried out on all standard tv channels. It was found to work successfully, as described, over the low band (channels 2 to 6). To obtain sufficient output for channels 7 to 13, the single-turn coupling link had to be removed from the oscillator tube itself and placed near components in the tube's circuit, underneath the front-end subchassis. This arrangement is illustrated in Fig. 2.

An alternate method may be used to check the local oscillator without the use of sweep generator or oscilloscope. In this technique, the grid dipper is also connected as shown in Fig. 2. The plate-voltage switch, however, is thrown to the OFF position, changing the instrument from an oscillator to an absorption device. The receiver is tuned to the channel to be tested and the dipper is set to the appropriate oscillator frequency. If the oscillator is operating and in proper adjustment, it will radiate energy into the coupling link of the grid-dipper. This will be shown by deflection on the instrument's meter. If there is no such indication, either the local oscillator is not functioning or it is operating at the wrong frequency.

Local-Oscillator Alignment

If the latter condition is the one that exists, the local oscillator can be retuned with a fair degree of accuracy with the aid of the grid-dipper. The grid-dipper must remain tuned to the correct oscillator frequency. The local-oscillator coil is then aligned for a peak on the grid-dip meter. In some cases, this peak will be rather broad, maintaining itself over a considerable range of adjustment of the oscillator coil. This can be counteracted by reducing coupling from the oscillator. The coupling link is moved away from the oscillator components until a sharp peak can be tuned on the oscillator coil.

Checking Alignment of I-F Coils

When a receiver is suspected of having a misaligned i-f strip, the grid-dipper is also useful for a reasonably close check of individual coils. The single-turn coupling loop is placed over the coil to be checked in the arrangement illustrated in Fig. 3. The test is conducted with the grid-dipper operated as an

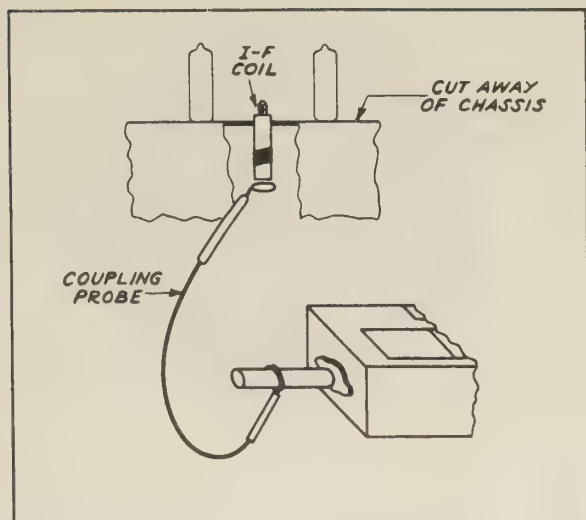


Fig. 3

oscillator (the plate-voltage switch in the ON position) and with receiver power turned off. A plug-in coil is chosen that will permit the grid-dip oscillator to be tuned through the range of frequencies over which the i-f coils should be normally adjusted. The grid-dipper tuning control is then rotated for *minimum* indication on the grid-dip meter. At this point, the reading on the tuning dial is the actual resonant frequency of the i-f coil assembly.

The i-f coil itself may then be aligned to its approximate frequency, if it is found to be mistuned. This is done by setting the grid-dip oscillator's tuning control to the desired alignment frequency and adjusting the tuning slug or trimmer on the i-f coil assembly for a dip, or minimum indication, on the grid-dip meter. A similar procedure may be employed to adjust sound traps or other traps in the video-signal portions of the receiver.

Checking Video-Amplifier Bandwidth

The grid-dipper, operated as an oscillator, also makes a handy marker generator. As such, it may be used to run a marker across a response curve to check correct placement of alignment points along the curve or to determine bandwidth.

It was tested in this capacity with a typical video-amplifier response curve, obtained with a sweep generator adjusted to sweep 0 to 10

mc, a crystal-detector probe, and an oscilloscope. The typical arrangement of these instruments is given in greater detail in CIRCUIT GUIDES III-1 and III-2. The response curve thus obtained is shown in Fig. 4.

The plug-in coil that provided the lowest range was then inserted into the grid dipper, which was tuned to 4 mc. Marker coupling was achieved by holding the probe's coupling link near components in the video-amplifier circuit. The curve thus marked appears in Fig. 5. Marker amplitude could be controlled easily by moving the probe closer to or away from the circuit components. When the grid-dipper's tuning dial was run down to 2 mc, the marker moved to the position shown in Fig. 6.

Although the grid-dip meter is a handy and valuable instrument, its accuracy, although

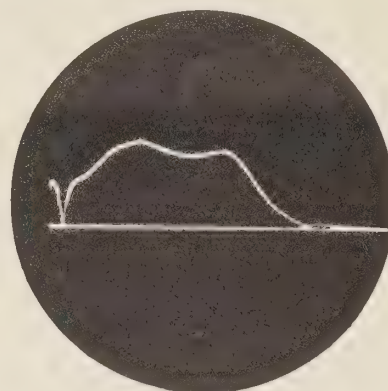


Fig. 4

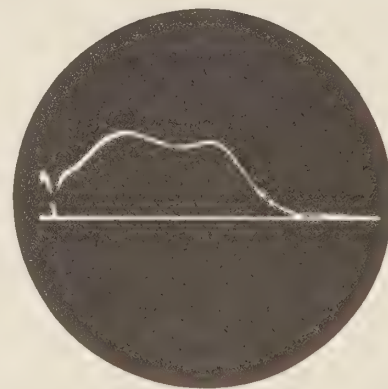


Fig. 5

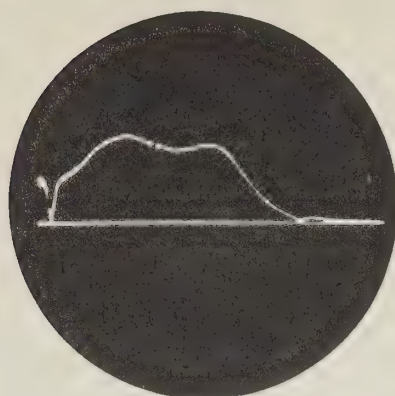


Fig. 6

very good, does not compare with that of a crystal-calibrated generator. The tests described here will give an approximate check of frequency adjustment and alignment; where greater accuracy is required, standard alignment procedures must be followed. However, since the grid-dipper may be used to determine whether such alignment is or is not necessary, even in such cases there is much saving of time in the needless setting up of test equipment for alignment where the set-up is not needed.

INSTRUCTIONS

for

GRID-DIP METER

Cat. No. 90651 - Serial No.

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U. S. A.

FREQUENCY IN KILOCYCLES

CALIBRATION OF LOW FREQUENCY INDUCTORS
FOR JAMES MILLEN *90651 OR *90661

GRID DIP METER

NO. 46702 925 TO 2000 KC.

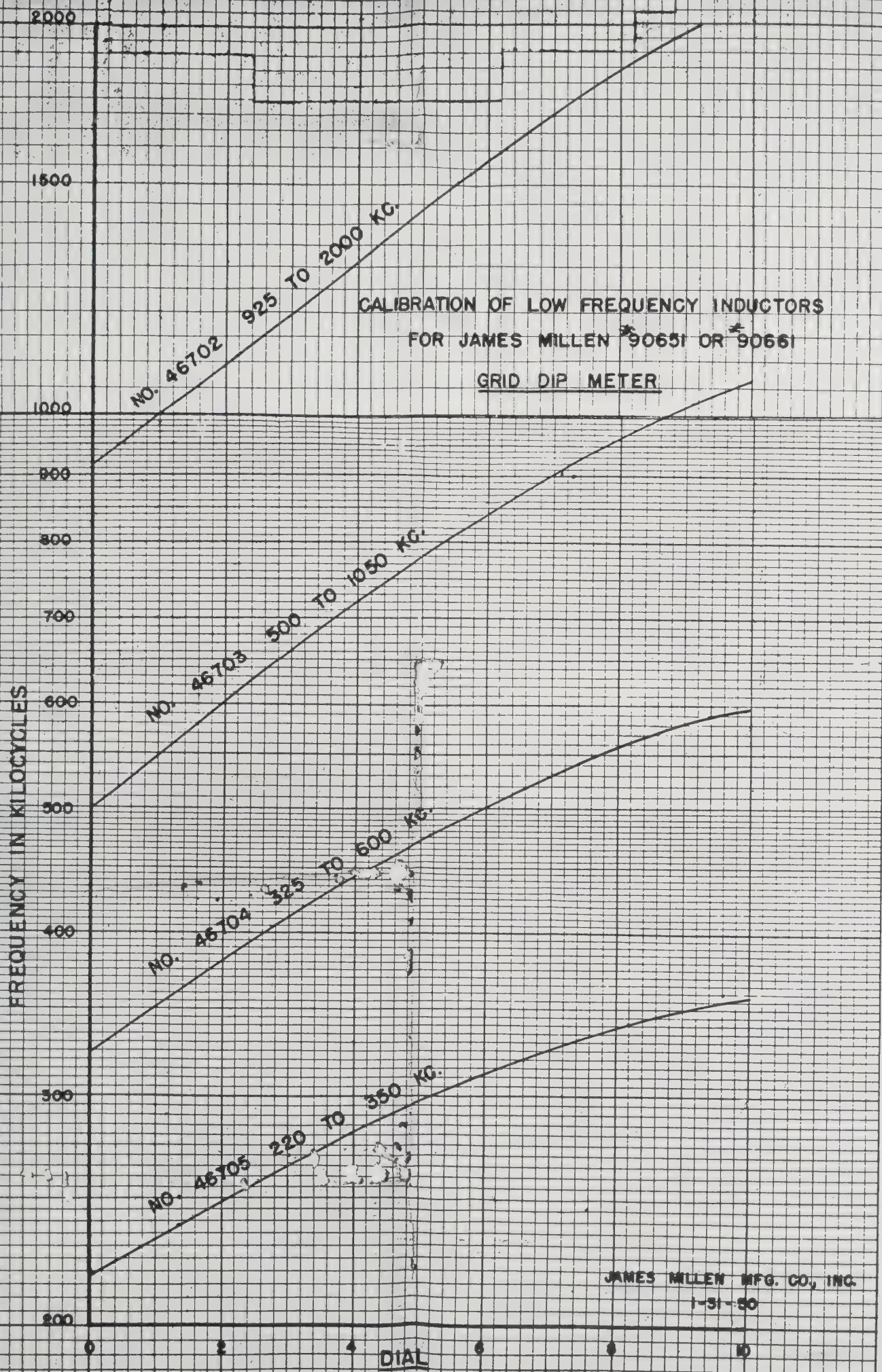
NO. 46703 500 TO 1050 KC.

NO. 46704 325 TO 600 KC.

NO. 46705 220 TO 350 KC.

JAMES MILLEN MFG. CO., INC.
1-31-50

DIAL



FREQUENCY IN KILOCYCLES

CALIBRATION OF LOW FREQUENCY INDUCTORS
FOR JAMES MILLEN 90651 OR 90661

GRID DIP METER

NO. 46702 925 TO 2000 KC.

NO. 46703 500 TO 1050 KC.

NO. 46704 325 TO 600 KC.

NO. 46705 220 TO 350 KC.

JAMES MILLEN MFG. CO., INC.
1-51-50

DIAL

2000

1500

1000

900

800

700

600

500

400

300

200

0

2

4

6

8

10

